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CIVIL ENGINEERING.

Contributions to Railway Statistics, in 1846, 1847, *and* 1848. *By* HYDE CLARKE, ESQ.

No. 1.—*Passengers and Fares.* Having published an analysis of the railway returns for 1845, I have taken the earliest opportunity after the appearance of those of 1846 and 1847, of giving a similar analysis of them, under the same title of "Contributions to Railway Statistics," which I hope may prove equally acceptable to practical men as the former series.

The following are the totals of each class of passengers in the years ending 30th June.

	1844.	1845.	1846.	1847.
1st class,	4,875,332½	5,474,163	6,160,354½	6,572,714
2nd class,	12,235,686	14,325,825	16,931,065¾	18,699,288½
3rd class,	8,583,085½	13,135,820	18,506,527½	22,850,803½
Mixed,	2,069,498½	855,445¾	2,193,126	3,229,357
Altogether,	27,763,602½	33,791,253½	43,790,983¾	51,352,163

The amount received for each class, in each year, was as follows:

	1844.	1845.	1846.	1847.
1st class,	£1,432,688	£1,516,805	£1,661,898	£1,675,759
2nd class,	1,375,679	1,598,115	1,937,946	2,048,080
3rd class,	483,069	651,903	1,032,206	1,286,710
Mixed,	147,858	209,518	93,164	146,733
Altogether,	£3,439,294	£3,976,341	£4,725,215	£5,148,002

The yearly increase in numbers on each class of passengers, is as follows:

	1845.	1846.	1847.
1st class,	12 per cent.	12 per cent.	7 per cent.
2d class,	17 "	18 "	10 "
3rd class,	50 "	41 "	23 "
Altogether,	21 "	24 "	17 "

The yearly increase in money on each class of passengers, is as follows:

	1845.	1846.	1847.
1st class,	6 per cent.	9 per cent.	— per cent.
2d class,	16 "	21 "	6 "
3rd class,	34 "	58 "	24 "
Altogether,	16 "	18 "	9 "

It is to be observed that no deductions can be drawn from these figures, as the Railway Department returns are defective and informal.

The gross returns in each year from passengers, goods, &c., were as follows:

1842–3,	£4,535,189
1843–4,	5,074,674
1844–5,	6,209,714
1845–6,	7,565,569
1846–7,	8,510,886

The capital expended on railways has been likewise given by Mr. Hackett, from which we can learn the amount expended in each year.

1842,	£52,380,100 whole capital,	—— expended.
1843,	57,635,100 "	£5,255,000 "
1844,	63,489,100 "	6,844,000 "
1845,	71,646,100 "	8,157,000 "
1846,	83,165,100 "	12,519,000 "
1847,	109,528,800 "	26,363,700 "

The total amount of railway expenditure from 1842 to the end of 1847, was £57,548,700.

The total amount of railway income in those years, has been:

1842,	£4,341,781
1843,	4,827,655
1844,	5,584,982
1845,	6,649,224
1846,	7,664,874
1847,	8,949,681
Add from railway returns,	865,984
Altogether,	£38,884,181

Of course the whole of this income cannot be treated as real capital, no more can the whole of the expenditure; but it is a significant fact, that while the whole expenditure has been £57,548,700, the whole income has been £38,884,181, or more than two-thirds of that amount. This is deserving the attention of those who direct their attention towards the subject of railway capital.

In "Irish Wants and Practical Remedies," by Humphrey Brown, Esq.,

M. P., (p. 63,) is given a table of the estimated passenger and goods traffic of several English lines, as given before the House of Commons. This I have extended. The results are as follows:

	Passengers.	Goods. Tons.
Estimated traffic on 851 miles,	4,135,836	1,038,504
Realised traffic, 1845,	10,868,503	2,751,180
Excess over estimates,	6,732,667	1,712,676
Increase per cent.	160	170

In Mr. Brown's book on a length of 702 miles, the same increase of per centage is shown, namely, 160 per cent. on passengers, and 170 on goods.

The whole traffic in 1845 was 33,791,253½ passengers, and of goods, &c., 11,600,000 tons. Supposing the proportions to be the same, the number of passengers carried in 1845 more than was provided with means of conveyance before the existence of railways, was 20,800,000, and the number of tons of goods conveyed was 7,200,000. Thus the railways not only accommodated the full number of passengers for whom conveyances already existed, but carried the above enormous number in addition, besides a great quantity of goods. It will be found that this calculation is, however, far from representing the amount of accommodation now afforded.

Taking the latter returns, where they are available, we shall find the increase still greater, as in 1846, for instance:

	Passengers.	Goods. Tons.
Estimated traffic,	4,135,836	1,038,504
Realised traffic, 1846,	13,718,503	3,530,441
Excess over estimates,	9,572,667	2,492,937
Increase per cent.,	230	250

The traffic on these lines stands as follows:

	Passengers.	Goods. Tons.
Estimated,	4,135,836	1,038,504
Realised, 1845,	10,868,503	2,751,180
" 1846,	14,078,697	3,530,441

The lines for which there are separate returns in 1847, are as follows:

Great Western, &c.	231 miles.
Glasgow and Ayr,	18¾ "
Lancaster and Preston,	20 "
Dundee and Arbroath,	16½ "
Sheffield and Manchester,	44½ "
South Eastern,	67 "
	297¾ "

The traffic stands thus:

	Passengers.	Goods. Tons.
Estimated,	2,378,995	529,618
Realised 1845,	5,138,041	604,641
" 1846,	7,006,625	891,333
" 1647,	7,382,586	1,236,081

The actual increase of traffic depends upon the length of time given for its development, beginning at 160 per cent. and going up to 230 per cent., and in the case of the selected railways, even more. Taking the increased accommodation to passengers at 160 per cent., this would give the following as the increased number of travelers provided with traveling accommodations in each year:

1844,	17,400,000
1845,	20,800,000
1846,	27,000,000
1847,	30,000,000

If the proportion be taken at 200 per cent., the number accommodated by railway, for whom no accommodation was before provided, would be 34,000,000.

The following shows the proportion of traffic on railways in each year for which accommodation by coach, &c. was provided, and for which no accommodation by coach, &c. was provided:

	Travelers from old coaches, &c.	New Travelers.
1844,	10,300,000	17,400,000
1845,	12,900,000	20,800,000
1846,	16,000,000	27,000,000
1847,	21,000,000	30,000,000

Reckoning that each passenger is on the average carried 20 miles, each male adult in this country will be carried that distance six times in the year,—an extent of accommodation which must have a great effect on trade, and on the distribution of labor.

It appears from the averages given in the returns of the railway department, that there has been a still further reduction in fare on most of the lines, and an increase in the average speed per mile.

The total increase on each class of passengers is as follows:

	1845.	1846.	1847.
1st class,	599,831	686,191	412,460
2nd class,	2,190,139	2,615,240	1,768,223
3rd class,	5,552,735	5,471,707	4,344,376
Altogether,	6,028,651	9,999,730	7,561,180

It is to be observed that these figures cannot be absolutely relied on, as the proportions of each class cannot be fully shown, on account of the confused state of the returns published by the railway department.

The total increase on each class of passengers between 1844 and 1847, has been as follows:

1st class,	1,697,392
2nd class,	6,463,602
3rd class,	14,267,718
Altogether,	23,588,561

This is probably more than the whole traffic of the country in 1825, and it shows at any rate that there has been a great increase in the accommodation given to the working classes.

No. 2.—*Cattle Traffic.* The last parliamentary returns are still more

defective than their predecessors, so that it is necessary to estimate some of the numbers.

The following shows the number of cattle carried in the year ending 1st July, 1846:

Cattle, - -	370,000
Sheep, - -	1,250,000
Swine, - -	850,000
Total, - -	2,470,000

This shows an increase of 25 per cent. over the number of animals carried in 1845.

On account of the very imperfect state of the returns, it is impossible to give the proportion paid in 1846 under each head of the cattle traffic. In 1845 the proportions were:

Cattle, - -	£30,000
Sheep, - -	26,000
Swine, - -	30,000

The proportion for cattle must now be larger, and that for swine smaller.

The whole number of cattle in 1847 will therefore be as follows, allowing for the incompleteness of the returns:

Cattle, - -	500,000
Sheep, - -	2,000,000
Swine, - -	390,000
Total, - -	2,890,000

Making nearly three million head of stock. The falling-off in swine arose from the Irish famine.

The total receipts for cattle traffic in each year were as follows:

1845, - -	£102,000
1846, - -	167,200
1847, - -	183,400

The great advance in cattle traffic was made in 1846; but the progress was not so great in 1847, as there was a positive falling-off in the number of swine carried. The greatest increase is in the conveyance of fat stock and sheep.

The following are the proportions of cattle carried in each year:

	Cattle.	Sheep.	Swine.
1845,	236,000	1,200,000	550,000
1846,	370,000	1,250,000	850,000
1847,	500,000	2,000,000	399,000

Civ. Eng. & Arch. Jour., Aug. 1848.

(To be Continued.)

Savings by Railways.

An "Observer," in the Morning Herald states that it has been estimated that railways have effected a saving of £12,000,000 annually on the traffic of the country, although they comprehend as yet but a fraction

relatively of the whole traffic of trade. Among other items of traffic he states that of building-stone to be not one-tenth of what is requisite for even a fourth part of the surface, "and whereas stone might be brought up to the metropolis at one penny per ton per mile, by the London and North-Western and Great Western Railways, little is so brought, though there is a great wish to have public buildings of stone instead of brick."

Lond. Build., Nov. 1848.

Report upon the Use of Anthracite Coal in Locomotive Engines on the Reading Railroad, made to the President of the Reading Railroad Company, by GEORGE W. WHISTLER, JR., *April* 20, 1849.

JOHN TUCKER, ESQ., *President.*

Sir:—Agreeably to your request that I should make to you a report of my observations upon the Reading Railroad, relative to the use of anthracite coal in Locomotive Engines, comprehending its present comparative results with the Engines burning wood upon that road, and its ultimate economy, deduced from such data as I am enabled to get from this and other roads using raw coal as fuel, I beg to submit the following statements:

The Comparison of Engines in their Consumption of Fuel.

The observations made by me upon the Reading Railroad, were between the 23d September and 26th October of the past year, during which time I was absent from the road for a period of two weeks, making examinations of a similar character upon the Hazleton and Beaver Meadow Railroads. The number of trips which I record are, 17 of the *Baltimore Coal Engines;* 5 of the eight-wheeled Coal Engine *Novelty;* and 3 of the eight-wheeled wood-burning Engine *Indiana.* There were four other trips made upon the *Baltimore Coal Engines*, but not taken into this account; two were broken by derangement to the Engine, and two were neglected, being way trips. Two additional trips were made with the *Novelty;* upon one the coal for the use of the Engine was lost, and upon the other a derangement of the Engine spoiled the trip. A fourth trip was also made upon a wood Engine, but with a way train, and is not included in this account.

I give you, further on, a statement of each trip as it was made, and from which I have calculated the table of comparative results.

For making these observations, I had every facility extended to me by Mr. G. A. Nicolls, the Engineer and Superintendent of the road, and all information relative to repairs of Engines necessary to a satisfactory comparison, furnished me. I was also permitted to take any Engines in the coal trade for trial, and run them over the road at such times as would subject them to the least delays, and give the most daylight for the observations. I availed of this privilege but twice; being desirous that the trips should be made under the same circumstances as those recorded each day of the wood Engines, which were running in their turn by the regulations of the road, and the quantities of fuel used (consumed or wasted) for each trip was recorded.

As care is taken to ascertain the quantities of fuel used by the wood Engines, a statement of which has been made to yourself by the Engineer and Superintendent, showing what that quantity was for July and August last, I have not considered it necessary to make observations upon these Engines, further than to ascertain if the frosty season of the year, during which they were made, caused any material difference in these results, but as I found none the trips were soon discontinued. With the coal Engines, however, the amounts of fuel consumed per trip have not been ascertained, and my observations have been directed more particularly to them. The fuel used for the coal Engines was, in all cases, noted as the difference in weight between that taken at one end of the road and that remaining at the other. Of the trips here recorded I made seven myself, two upon a *Baltimore Engine* and five upon the *Novelty;* and was assisted in the remainder by young men whom I put upon the Engines.

BALTIMORE COAL ENGINES.

Direction.	Date.	Engine.	Load.	Fuel.
Richmond to Pottsville,	Sept. 23	Delaware,	100 Cars.	4·25 Tons.
Pottsville to Richmond,	" 24	"	95 "	4·50 "
" "	Oct. 11	Ohio,	95 "	5·55 "
Richmond to Pottsville,	" 12	"	100 "	5·30 "
Pottsville to Richmond,	" 13	"	95 "	5·15 "
Richmond to Pottsville,	" 14	"	100 "	5·00 "
Pottsville to Richmond,	" 14	Maryland,	95 "	4·00 "
Richmond to Pottsville,	" 16	"	94 "	3·50 "
Pottsville to Richmond,	" 17	"	85 "	5·25 "
Richmond to Pottsville,	" 18	"	94 "	4·75 "
Pottsville to Richmond,	" 19	"	85 "	4·75 "
Richmond to Pottsville,	" 20	"	94 "	4·50 "
Pottsville to Richmond,	" 21	"	85 "	5·30 "
Richmond to Pottsville,	" 24	"	94 "	4·75 "
Pottsville to Richmond,	" 25	"	85 "	5·05 "
Richmond to Pottsville,	" 23	Delaware,	94 "	4·50 "
" "	" 26	"	94 "	3·80 "
Total quantity of coal used on 17 trips, ...				79·90

9 trips up, coal used = 40·35 = 4·45 per trip.
8 " down, " = 39·55 = 4·95 " = 9·40 per round trip.
Average load down, 90 cars, with 450 tons of coal.

As the results here given are inclusive of all waste, a deduction should be made, and a quantity of coal somewhat nearer that actually consumed taken for a comparison with wood. The coal supplied for Locomotive Engines to the Reading Road is of good quality, (Forest Improvement,) the only drawback being the large per centage of fine coal and dirt intermixed with it. Cars containing 5·5 tons in weight, have in them from a half to one and a half tons of this dross, a part of which is thrown from the tender upon the road and estimated as fuel consumed.

This waste amounts to about half a ton per trip; I propose, however, to deduct but five per cent. from the gross weight, as that allowance is made by the parties furnishing coal, and has no corresponding equivalent in wood.

Five per cent. deducted from 79·9 leaves 76 tons of coal for 17 trips.
Trip up = 4·25 tons. Trip down = 4·75 tons. Round trip = 9 tons.

ENGINE NOVELTY.

Direction.	*Date.*	*Load.*	*Fuel.*
Richmond to Pottsville,	Oct. 10	85 Cars.	5·75 Tons of Coal.
Pottsville to Richmond,	" 11	80 "	6·00 "
" "	" 13	71 "	5·45 "
Richmond to Pottsville,	" 14	85 "	5·50 "
Pottsville to Richmond,	" 16	72 "	5·40 "
		Total quantity of coal used in 5 trips,	28·10 Tons.

2 trips up, coal used 11·25 = 5·62 tons per trip.
3 " down, " 16·85 = 5·63 "
Coal used per round trip, 11·25
Deduct 5 per cent. for waste, 10 70 tons per round trip.
Average load down, 75 cars, with 37½ tons of coal.
The fuel used Oct. 16th, includes half a cord of wood, which is estimated as one quarter of a ton of coal.

ENGINE INDIANA.

Direction.	*Date.*	*Load.*	*Fuel.*
Richmond to Pottsville,	Oct. 9	95 Cars.	6·87 Cords of Wood.
Pottsville to Richmond,	" 10	88 "	7·37 "
Richmond to Pottsville,	" 11	95 "	7·13 "
		Total quantity of fuel used on 3 trips,	21·37 Cords.

2 trips up, wood used 14 cords = 7 cords per trip.
1 trip down, " 7·37 " = 7·37 "
Wood used per round trip with 88 cars down, containing 440 tons of coal, 14·37 cords.

By the reports for the months of July and August, the fuel used for the Engine *Champlain*, weighing 20 tons, on six driving wheels, with cylinders 16 in. in diameter by 18 in. stroke, and working its steam expansively, is 10·25 cords of wood per round trip of 190 miles.

The fuel consumed by the Reading-built six-wheeled Engines, shown in the statement for comparison, is taken from the report for July and August already referred to, as well as the average quantity of fuel per trip for all wood Engines in the coal trade during that time. The quantity and cost of fuel per 100 tons of coal transported, as shown in the summary of the foregoing observations, includes the return trips with empty cars, the power exerted in either direction being very nearly the same.

The Reading Railroad is 95 miles in length, with a total fall of 600 feet—greatest fall at any part of the road, 20 to 25 feet per mile; it has no ascending grades in the direction of the trade, except within five miles of Philadelphia, where assistant Engines are stationed. The return load for each Engine is about one-third the entire gross weight of train brought down, which is the weight of cars alone.

Weight of cars, 2·5 tons, coal in cars, 5 tons.

Total weight of coal and car, 7·5 tons of 2240 lbs.

Cost of wood in the following statement, $4 per cord, do. of coal, $2·75 per ton of 2240 lbs.

To facilitate a comparison of the various Engines on the road, a short description of their principal features is given.

Engine Novelty.

Engine on eight driving wheels, 46 inches diameter. Boiler on a separate carriage behind the Engine, and connected with it by flexible steam

pipes, (a system of ball and slip joints;) weight of Engine 21·5 tons. Diameters of cylinders 18 inches, and length of stroke 20 inches. Area of fire grate 36 feet, fire surface 1085 feet. Placed upon the Engine is a cylinder of boiler iron about 42 inches in diameter, and 18 feet long, having a connexion with the water-tank, immediately behind the boiler. This cylinder of boiler iron answers the double purpose of giving adhesion to the Engine, and as a condenser for the exhaust steam from the cylinders, by which the water from the tank is heated before passing into the boiler; the combustion of coal is promoted by a fan blast.

Baltimore Engines.

Total weight of Engines with coal, fuel and water, 27 tons; weight on eight driving wheels 25 tons; do. on two small trailing wheels, 2 tons; diameter of boiler 42 inches; length of tubes 14 feet; diameter of do. $2\frac{5}{8}$ inches; area of grate 18 feet; fire surface 957 feet; diameter of driving wheels 46 inches; diameter of cylinders 16·5 inches, and length of stroke 20 inches; the draft is regulated by the variable exhaust in the smoke stack; steam cut-off in the cylinders at half stroke.

Eight-Wheeled Wood Engines.

Total weight of Engines 22·5 tons, on eight driving wheels 46 inches in diameter. Cylinders 15·5 inches in diameter, and 20 inch stroke; fire surface about 875 feet; area of grate about 12 feet.

Tabulated Comparison of Engines on the Reading R. R.—Fuel Consumed.

Name or Class of Engines.	Number of driving wheels, each 46 in. diameter.	Weight on driving wheels.	Coal transported per trip by regulations of road.	Total gross load per round trip.	Coal transported per ton of adhesion.	Fuel consumed per round trip of 190 miles.	Water evaporated.	Fuel consumed per 100 tons of coal transported.	Cost of fuel per 100 tons of coal transported.	Comparative consumption of fuel.
		tons.	tons.	tons.	tons.	Tons of Coal.	galls.			
Baltimore Eng.	8	25·0	450	900	18·00	9·00	14,400	2·000	5·50	1·00
Novelty,	8	21·5	375	750	17·44	10·70	14,400	2·853	7·95	1·43
						Cords of Wood.				
Baldwin Large,	8	22·5	420	840	18·66	13·75	16,200	3·273	13·09	1·64
" "	6	19·5	375	750	19·23	13·00		3·467	13·87	1·73
Champlain,	6	20·0	375	750	18·75	10·25		2·733	10·93	1·37
Reading Eng.,	6	20·2	375	750	18·56	13·50		3·600	14·40	1·80
All Engines—July and Aug. per report of Mr. Nicolls,			400	800		13·42		3·355	13·42	1·68

The water evaporated in the Novelty's boiler does not include the condensed steam from the exhaust, a large portion of which forms a constant supply to the boiler.

The foregoing statement shows an accurate comparison of the coal and wood-burning Engines upon the Reading Road in their consumption of fuel; and as the observations have extended over a considerable time, I have no doubt these quantities will be found very near the actual consump-

tions per trip, during the mild seasons of the year, for then the delays are unimportant, and but few broken trips occur to swell the averages; still, as it is understood that the comparative and not the actual quantities of fuel consumed by each class of Engines is the information sought for, any want of accuracy in estimating the latter is unimportant.

I am aware that the results just given of the consumption of fuel differ from those given by Mr. Nicolls in the report made to yourself last fall. He there says, that in the spring of 1848 the Baltimore Engines used 9·64 tons of coal per round trip, but that great care was taken in the selection of fuel, and in running the Engines; and he further says, that it is his belief that the every-day consumption of fuel by these Engines is about 12 tons per round trip. That Mr. Nicolls is mistaken in his belief the facts will show; and he has allowed himself to be lead into this error by drawing hasty conclusions from unanalogous facts. Thus, as the experiments made in the spring of the last year show that 390 tons of coal were transported with an average expenditure of 10·89 cords of wood, and that 425 tons of coal were transported by the *Baltimore Engines* with a consumption of 9·64 tons of coal; that this proportion holds good between the wood and coal Engines at all times; and therefore, as the actual amount of fuel used by all the wood Engines, during the months of July and August, was 13·42 cords per round trip, transporting 423 tons of coal, the *Baltimore Engines* had consequently consumed about 12 tons of coal in transporting 475 tons of coal.

In determining the excellence of a Locomotive Engine, one of the most important points to be considered is the ability to generate an abundance of steam at all times, not only to do the work required of the Engine when all things are favorable to its well-working, but under ordinary or even adverse circumstances. To insure this, there is required for an Engine the power to burn a large or small quantity of fuel in a given time, and to this end a large fire-place and area through the tubes are necessary, with the means of increasing or diminishing at pleasure the blast of the exhaust steam. By such an arrangement the Engine-man has under control the draft through the fire, and with it the consumption of fuel, but upon the judicious management of this power, depends the merit of this first excellency in a Locomotive Engine.

The Baltimore Coal Engines have the abundance of steam-generating power for all emergencies, and under the control of the Engine-man; but the nature of anthracite coal as a fuel for Locomotive purposes, and the want of experience in its use, will prevent, for a time, that degree of economy in its consumption which is attained with wood under the same circumstances, but by long experience.

The Reading Railroad Company have at present but few coal-burning Engines on their road; and as these have been in use but a few months, and no roads using anthracite coal furnish to it available experience, it is not to be expected that a comparison of the utmost economy of coal and wood, made in the spring of 1848, can be made the basis for a rule-of-three method of arriving at the present every-day consumption of this fuel; facts disprove it; for it will be seen by my own observations, that the average amount of fuel consumed during the ordinary working of these Engines for several successive days, over the road, does not exceed these last spring

experiments, while single trips were made with very much less fuel; it is well known, also, that the Engines have not unfrequently been run with little more than one-half this consumption of fuel; but the want of experience in the use of anthracite coal with Locomotive Engines having the cut-off, and variable exhaust, has been a great drawback to the constant economical consumption of this fuel.

The success attending the use of anthracite coal upon the Beaver Meadow and Hazleton Railroads induced numerous attempts to be made by the Reading and other Railroad Companies, to introduce this fuel by similar means upon their own roads; but the length of road and heavy business to which the Engines were subjected soon proved its impracticability; showing, moreover, that the successful burning of anthracite coal upon the Beaver Meadow and Hazleton Roads does not depend so much upon the peculiarities of their Engines—consisting in an absence of ash-pan and the exhausting in numerous small jets up the smoke stack, for the purpose of equalizing the draft through the fire—as it does upon the short roads (each 14 miles) and the small amount of work done by each Engine; and my observations upon these roads convinced me that their own success falls short of the requirements of the Reading Road.

Now, while the quantity of fuel consumed per round trip, under the most favorable circumstances, in the *Baltimore Engines*, is stated by Mr. Nicolls to be 9·64 tons of coal, my own observations upon the every-day working of the road show, in one case, but 7·5 tons per round trip, and I have reason to believe that round trips have not unfrequently been made with as little as 6 tons of coal. Again, while Mr. Nicolls estimates that 12 tons of coal per round trip is the every-day consumption of fuel, the average of my own observations on seventeen trips is but 9 tons, and the daily observations of the Superintendents of Engines and Machinery at either end of the road, does not lead them to give a higher estimate than 9 tons per round trip.

In explanation of the excess of fuel used in the wood-burning Engines during the months of July and August, over the experiments made in the spring, Mr. Nicolls says that the quantities of fuel include that used for way and broken trips, which always swell the averages. The way trips are a very small proportion of the trips through (one in ten); and if broken trips have reference to short trips caused by accidents, these can have increased the quantities of fuel used per trip but slightly; for during July and August the road was remarkably free from accidents, I believe entirely so.

By last year's annual report, Mr. Nicolls estimates that 1,360,000 tons of coal were transported during twelve months, in average loads and with an average consumption of fuel per Engine as follows:

354	tons	transported	with	15·83	cords	wood	in 1847.
423	"	"	"	13·42	"	"	July & August, 1848.
69	" more	"	"	2·41	"	"	less.

There may be great economy in the consumption of fuel this year over that shown in the report for last year; but I doubt if the quantities for July

and August could be reduced, for the work done, below the statement made above.

With respect to the *Novelty*, and her performance as a coal-burning Engine, I have little to say; I was so fortunate as to see the Engine for several successive days, under admitted favorable circumstances, and though it made good time over the road, I could but agree in the opinion generally entertained and expressed of its entire impracticability.

It may be a matter of surprise that this Engine, provided with a condenser, and having twice the area of grate that the *Baltimore Engines* have, should consume nearly half as much more fuel in doing the same work; but a large per centage of the steam generated is required to drive a fan; and again, there is a loss by condensation and leakage in the steam pipe leading from the boiler to the cylinders, which is about thirty feet long, and greatly exposed; there is also a waste of fuel in the fire-place, caused by its very great size, the heat being so intense from the mass of fire exposed, as to prevent the men from clearing the grate of cinder, except just at the door, and consequently the cinder and coal accumulate upon the grate, and the blast has gradually to be increased as the Engine progresses on its way. The loss of fuel from this cause is apparent on the last twenty miles of each trip, the gases formed by the partial combustion of coal being burned at the chimney top.

To be Continued.

Increased Draft in Locomotive Flues.

A patent has been taken out by Mr. E. Albon, for an apparatus for regulating and increasing the draft in locomotive chimneys. It consists of a pipe of copper, or other suitable material, affixed to the chimney, one end of which is bell-mouthed and open to the atmosphere, and the other turns upwards into the smoke-box in a perpendicular direction: the blast or steam-pipe passes up through the bend, and, by its exhausting action, it is stated, causes the air which passes in at the bell-mouth, to rush rapidly through the same into the chimney. By this means, it is said, the current will be regular, though the steam is intermittent.

Lon. Build. Nov. 1848.

London and North-Western Railway.

The Euston station, which has been recently completed by Messrs. Braure and Gwyther, of Birmingham, at a cost of about £150,000, is situated between Seymour street and Whittlebury street, and comprises an area of about 2100 feet in length, by 500 feet in breadth. On either side is a platform; the one on the east, or the arrival platform, is 1100 feet in length, and about 40 feet in width; and the departure platform is about 800 feet in length. In this space on the various lines there are 60 turn tables, and over this are about 700 feet by 350 feet of glass roofing. There are also 16,000 feet of drains and sewage, which have been constructed under the direction of Mr. M. A. Watkins. On the west side, adjoining Codrington street, a number of coach factories have been erected, the area occupied by these being 300 feet by 400 feet. A smithey, with every

convenience for the manufacturing of vehicles, is attached. In the course of the past week the waste materials which were not required by the contractors, were sold, and realized nearly £1000.

The following is the number of persons employed on account of this company, including those occupied in the collection and delivery of goods: 2 secretaries, 1 manager, 2 superintendents, 966 clerks, 3054 porters, 701 police constables, 738 engine and firemen, 3347 artificers, 1452 laborers; total number, 10,263. The number of horses employed is 612; ditto vans, &c., 253. Lond. Min. Journ, Dec. 2, 1848.

Report to the President and Directors of the Ohio and Pennsylvania Railroad Company. By SOLOMON W. ROBERTS, *Chief Engineer.*

(With a Map.)

One of the greatest enterprizes ever undertaken in America, is the Great Central Railroad of Pennsylvania from Philadelphia to Pittsburg.

But it can never take rank as the first of all the thoroughfares between the East and the West, until it is connected with the railroads of Ohio, and of the States further west.

To accomplish this connexion is the primary object of the "OHIO AND PENNSYLVANIA RAILROAD."

For this purpose the Company has been granted a perpetual charter by both the States which have given it their names. The Corporation is a unit, with concurrent powers in both Commonwealths; and certified copies of the necessary laws have been interchanged between their respective Governors.

Most of the railroads in the State of Ohio run in a northerly and southerly direction, to connect the Ohio river with Lake Erie. The general direction of the "Ohio and Pennsylvania Railroad" is easterly and westerly, running over the elevated and highly cultivated table lands, and intersecting the other roads.

It will thus become a "BACK-BONE LINE, of which they will represent the ribs.

The road begins at Pittsburg, where the "Pennsylvania Railroad" ends. The first points west of Pittsburg, fixed in the charter, are Canton, the county town of Stark county, Ohio, 92 miles from Pittsburg, and Massillon, the great wheat mart of Ohio, on the Ohio canal, 101 miles from that city.

Very extensive and elaborate surveys have been made to ascertain the shortest, cheapest, most productive, and best line between Pittsburg and Canton and Massillon.

Soon after my appointment as Chief Engineer of the Company, the surveys were begun, under my direction, on the 11th of July, 1848, and they have resulted in proving the important fact, that the best route for the railroad, in a commercial sense, is also the best in an engineering point of view.

Commencing at the twin-cities of Pittsburg and Allegheny, the line continues along and near the northerly bank of the Ohio river to the mouth of the Big Beaver river, a distance of twenty-five miles.

It may conduce to perspicuity to consider the road, in the first instance,

in separate divisions. And as this report is based upon our preliminary surveys, my object will be to give correct general views rather than much minute detail.

From Pittsburg to Beaver, 25 miles.

This portion of the road, being in the valley of the Ohio river, on its northern side, is estimated to cost $10,000 *per mile, for grading and bridging*. This supposes the work to be done in a substantial manner, for a single track and turnouts. It would be easy to make a lower estimate; but, considering the importance of this part of the road, a less sum ought not to be expended upon it. The public is too often misled by insufficient estimates of the cost of such enterprises; but it should never be forgotten that only a certain amount of work can be done for a certain sum of money; and, on main trunk-lines, if the means required to build them *well* cannot be raised, it only shows that the time for beginning them has not arrived.

There are few places in the United States where a piece of railroad is likely to pay so well as between Pittsburg and Beaver.

The valley of the Ohio river here is the narrow neck of a vast funnel, of which Pittsburg is the outlet, and which expands at the mouth of Big Beaver, to the north-west towards the lakes, and to the south-west towards the Mississippi.

At Pittsburg the Pennsylvania Canal terminates, and at Beaver the canal connecting with Lake Erie, at Erie and Cleveland, begins. The termini of these canals have no canal connexion, and the only land carriage is by a common country road. The Ohio river, between these points, is a broad, rapid, and shallow steam, falling 35 feet in 28 miles, and having, in low water, a narrow and crooked channel obstructed by bars. In summer and autumn the droughts stop all but the smallest class of steamboats, and in winter the navigation is sometimes closed by ice. These facts are well known to the merchants and manufacturers of Pittsburg, as well as to the hotel-keepers and the traveling community. The remedy is obvious. A railroad, 25 miles long, will carry people in an hour, where they are now often detained on steamboats half a day.

Without taking into the account the passengers on the larger boats, an examination of the books of the small steamboats plying between Pittsburg and Beaver has shown that they carry, on an average, 163 passengers *each way* per day, or 326 in the two directions between those points. If we follow the English rule of multiplying by four to estimate the number of passengers that will travel after good railroad facilities are established, it will give us 1300 passengers per day, which, of itself, without counting anything for freight, or anything for through travel, would more than justify the construction of this portion of our road.

If we estimate for only 600 passengers per day throughout the year, at 50 cents each, it will give us $300 per day, to which we may add half that sum, or $150, for freight and merchandize of all descriptions, making $450 per day; which, multiplied by 313 working days per annum, gives a product of $140,850 gross receipts. If we deduct one-third for expenses, there will remain a balance of $93,900 net receipts, or more than 15 per cent. per annum on an invested capital of $600,000; supposing so large a

sum to be invested in constructing, furnishing, and stocking the first or city division of the road, extending from Pittsburg to Beaver, 25 miles.

If any one considers the foregoing to be an extravagant estimate of travel, let him recollect the fact that on the Glasgow and Greenock Railroad in Scotland, which competes with the steamboat navigation of the tide-way of the Clyde, the introduction of the railway, with low fares, has increased the number traveling from 110,000 to 2,000,000 per annum, being an increase of 19 fold, and equal to five times the population of the district.

We may estimate the population of the twin cities of Pittsburg and Allegheny, with the contiguous towns, at 70,000, and that of Beaver, including Brighton, Rochester, and the adjacent villages, at 10,000. Pittsburg has vast steam power, and Beaver great water power. Both are important manufacturing towns, united by numerous and constantly increasing commercial ties. Pittsburg is the greatest place in the west for the working of iron, and Beaver ought to be the greatest for the grinding of flour. In my opinion, the construction of our railroad, passing through four of the best wheat counties of Ohio, will make it so.

The population of both is rapidly increasing, and, with the increase of facilities, the travel will increase in a compound ratio, and Beaver will become a suburb of Pittsburg. The land along the line will be brought, as it were, close to the city, and will be valuable for many purposes, and especially for kitchen-gardens, dairy-farms, and country seats.

There need be no fear of the construction of a rival railroad between Pittsburg and Beaver. On the same side of the river space cannot be found for it, and on the opposite side a road would have to encounter the cost of two enormous bridges, which must be so lofty as to clear the tall chimneys of the largest steamboats at the highest water, making the track so high as to be out of the reach of facilities for business. No other plan seems open to a railroad attempting to enter Pittsburg on the south, unless it be by a line built on the river, cutting off Sligo from its river front, and crossing above the Monongahela bridge. Such a line could not, by any convenient means, connect with the Pennsylvania Railroad, excepting at a point on the Monongahela, some miles above Pittsburg.

On the whole it is clear that our road between Pittsburg and Beaver must be a most profitable investment, provided it be judiciously constructed and managed, and provided the requisite funds are obtained, so as to protect the interests of the stockholders, and not to permit financial sacrifices to add to the cost of the work.

Wherever a railroad is begun for which the whole capital required to complete it throughout cannot at once be raised, it is highly important to finish and bring into speedy use some portion of the most productive part of the line, the usefulness and success of which will insure its extension.

Such a course secures original subscribers to the stock from loss, and gives confidence to capitalists, who are thus induced to seek the stock as a profitable investment, and to furnish the funds for the rapid extension and completion of the work.

One main cause of the remarkable success of the railroad companies in New England has been their not beginning more than they were able to finish; and the losses on such enterprizes, experienced in some other parts of the Union, are to be attributed, not so much to bad engineering, as to

the pursuit of a contrary policy, which, preferring the counsel of hope to that of experience, and beginning the work along an extended line with insufficient capital, has resulted too often in swamping the company in debt, and compelling it to submit to the most injurious financial sacrifices.

While our work is in its infancy, we have the opportunity of profiting by all the experience of the past, in order to make its success certain.

From Beaver to Salem and Mount Union.

On this part of the line we reach the elevated table-lands of the State of Ohio, so favorable for railroad construction, and so celebrated for the production of wheat.

Under the head of Ohio, in a book on the Public Works of the United States, published in 1840, by the distinguished geographer, Henry S. Tanner, there is a remarkably correct description of the topography of the State.

Mr. Tanner says: "Westward from the valley of the Allegheny, *that of the Beaver exhibits the commencement of the* CENTRAL PLAIN, which divides the basins of the Mississippi and St. Lawrence. This plain stretches westward, and, widening in extent over the States of Ohio, Indiana, and Illinois, reaches the Mississippi river."

It is over this elevated plain that the route of our railroad runs, and our point of divergence from the Ohio river is at the mouth of the Beaver, which is the first practicable point of divergence west of Pittsburg.

To quote again from Mr. Tanner's book, he says: "For the construction of canals and railroads, the entire region comprehended by the States of Illinois, Indiana, Ohio, and Michigan, presents fewer impediments to the construction of such works than any other with which we are acquainted." "Perhaps the best idea of the topography of Ohio may be obtained by conceiving the State to be one vast elevated plain, near the centre of which the streams rise, and in their course wear down a bed or valley, whose depth is in proportion to their size, or formation of the earth over which they flow; so that the hills, with some few exceptions, are nothing more or less than cliffs or banks, made by the action of the streams; and, although these cliffs or banks, on the rivers or larger creeks, approach the size of mountains, yet their tops are generally level, being the remains of the ancient plain."

The results of our surveys corroborate the foregoing description. The southern and south-eastern parts of Ohio are cut up by the deep and crooked valleys, in which numerous streams flow on their way to empty into the Ohio river. Railroad lines following these streams must be very crooked, and lines crossing the streams and the intervening ridges must encounter still greater difficulties.

We have found that *the northern route, which we have adopted, turning the hill country on its northern flank, is the shortest and best route to the table lands of Ohio.*

It has also the advantage of crossing the streams where they are small, thereby reducing the amount of bridging required, as we cross no stream where it is large, excepting the Beaver at New Brighton, which at that point may be readily bridged.

The northern route, by Salem, by means of its connexion with the Cleve-

land Railroad near Mount Union, will afford the shortest and best line between Pittsburg and the important city of Cleveland on Lake Erie; 75 miles of the distance being traversed on our road, and 60 on the Cleveland road. The line will cross the river-hill summit near the present mail stage route. The summits here are materially lower than on the more southern lines, and our course has less curvature and a shorter distance. This matter has been very fully investigated, and the results of our preliminary surveys show, that of the different lines examined, the one by way of Yellow creek comes next in order to ours, and that, from Pittsburg, ours has an advantage over it of about ten miles in distance, to Cleveland on the lake, and seven miles to Canton, Massillon, and the west. If we adopt the usual estimate of $50,000, as the amount of capital, which is equivalent to the saving of one mile of absolute distance on a great railroad thoroughfare, this will make a difference of $500,000 in favor of our road as a route to the lake, and of $350,000 as a route to the west, and *both these advantages are combined by us in one line.*

Besides which, in view of the construction of rival roads to Wheeling, it is evidently of the first importance to the interests of Pittsburg, that her GREAT WESTERN RAILROAD *should strike the Ohio river as high up as possible, which our line does at Beaver.*

A line has been talked of from Pittsburg across the hill country of Washington county, and through a portion of the territory of Virginia, to strike the Ohio river opposite Steubenville, and to connect by means of an immense bridge, with a railroad chartered in Ohio, to terminate at that place. Such a line would encounter much unnecessary elevation for the purpose of cutting off the northern bend of the Ohio; it would be of no avail as a line to Lake Erie, or to those rich agricultural counties traversed by our road; and even as a line to Cincinnati and south-western Ohio, the saving in distance would be inconsiderable. Assuming $5000 as the average cost of grading and bridging a mile of railroad in Ohio, the bridge at Steubenville, if built in such a way as not to obstruct the navigation, would probably cost as much as the grading and bridging of *fifty miles* of such railroad. The distance down the river bank from Steubenville to the Wheeling bridge is about 20 miles. The difficulty of bringing such a line into Pittsburg without obstructing the harbor has already been adverted to; and if it should ever be constructed, it will probably connect with the "Pennsylvania Railroad" at or near the mouth of Turtle creek, on the Monongahela.

Many persons are misled, when judging of railroad routes, by what they see on ordinary maps of the course of common roads, forgetting that such maps do not indicate the elevations of the ground, and give very imperfect information as to the distances by railroads of moderate grades and curvatures in a broken country. If, in order to avoid bridging the Ohio, a railroad should be brought from Steubenville to Pittsburg, along the river bank, via Wellsville, the distance to Cincinnati by that route will be greater than by our "back-bone line," diverging at Beaver, and if the route across the country and across the river be adopted it will be very little less, and the important towns at the mouth of Beaver will not be touched, though they are more populous and important than Steubenville.

Heavy bridges cost much to build them and much to keep them up, and are liable to casualties from fire and flood. If of long span, great ex-

pense is required to make them stiff enough for locomotive engines; they need watchmen, and are not easily insured.

The results of our preliminary surveys conclusively show that our route from Beaver and New Brighton, by Salem, to Mount Union, possesses a combination of advantages not to be met with on any other line. The distance from Beaver to the point of intersection with the Cleveland Railroad, near Mount Union, will be about fifty miles; and progress will speedily be made in the definite location of the line, the experimental surveys of which have been already tested. The passes of the natural summits of the river hills, from which the selection of a point of crossing is to be made, vary from 450 to 500 feet above low water at the mouth of Beaver, being a less elevation than on the more southerly routes. In reaching the summit between Big and Little Beaver, grades of from 40 to 50 feet per mile will be required; the latter of which is the maximum used on the Western Division of the "Pennsylvania Railroad."

The line which we have adopted traverses the broad belt of elevated, highly cultivated, and populous table-land which intervenes between the Sandy and Beaver canal on the south, and the Pennsylvania and Ohio canal (commonly called the "cross-cut" canal) on the north, and not far from the centre of which the flourishing town of Salem is situated. On an average, our "back-bone line" is about ten miles north of the Sandy and Beaver canal, and twenty miles south of the "cross-cut" canal. We traverse a very fruitful country, inhabited by a moral, industrious, and thriving population, who now have no communications but common country roads, made over an alluvial soil, and very bad in wet weather. The expense of land carriage is so great that, in my opinion, the increased value of real estate, caused by the construction of our railroad, will more than equal the whole cost of it, without reckoning its other advantages.

In Beaver county our line opens an extensive field of bituminous and also of cannel coal, both of excellent quality. For making steam, for making gas, and for domestic use, the cannel coal is a most beautiful fuel, and the bed is about eight feet thick. We will thus have every opportunity of obtaining for our locomotives the best fuel at the lowest rates, and of reducing the expense of motive power to a minimum. Those familiar with the management of railroads in operation best know the importance of this advantage. Cheap fuel is the first element of cheap transportation. The same cause which enables us to carry cheaply, will also give us a heavy tonnage to carry, for the coal trade upon the line will be of great magnitude and importance.

These are some of the reasons why the interior route which we have adopted is preferable to a route along the river shore below Beaver. Instead of being hemmed in by the river on one side and the hills on the other, we have a broad tract of open country tributary to our line on both its sides. The table-lands are very favorable for the construction of improvements, and we have reason to expect branches, either by railroads or plank roads, both from Newcastle and Warren.

The distance from Beaver to the State line will be about twenty miles, estimated to cost for grading and bridging $10,000 per mile. After crossing the State line into Ohio, we estimate the average cost of grading and bridging at $5000 per mile. These estimates are for a substantial single

track railroad with the necessary turnouts, the usual maximum grade being forty feet per mile, and the minimum radius of curvature one thousand feet. In many places, where the ground will readily admit of it, it is intended to grade the road-bed wide enough for a double track in the first instance.

It has been represented by parties locally interested in diverting our railroad to the town of Wellsville, and to the mouth of Yellow creek, on the Ohio river 50 miles below Pittsburg, that our line to Mount Union could not be materially shorter than one in the Yellow creek valley, because Wellsville is not very far from a straight line drawn on an ordinary map from Pittsburg to Cleveland. But if any one will take the trouble to draw such a line, he will see that it crosses the river twice, and that Beaver, where our line diverges from the river, and which is the most northerly point upon the Ohio, and where its southerly bend begins, is the true point from which a fair comparison of distances must be made. The results of actual and repeated surveys have, however, conclusively answered this question.

We are not engaged in locating a paper railroad nor a local line. The work which we have in hand will be the second link in the shortest and best chain of railroads between the eastern Atlantic cities and the vast west, of which the first link is the Pennsylvania Railroad.

Our road will be the Union line between the railroad system of Ohio, the first agricultural State, and that of Pennsylvania, the first manufacturing State in the Union. Where we connect them these States are contiguous and divided but by an imaginary boundary. When its importance is duly considered, the claims of most other railroads which are urged upon public attention sink into insignificance in comparison. Gradually the public mind will become aware of the truth of this fact.

Such being the case, it becomes us to act with caution and firmness, aware that as we do our work well or ill, it will be a lasting honor or a lasting disgrace to us. In determining the route between those town which are made fixed points by the charter, or which become so on account of the topography of the country, that line which is best for the general public will also be the best for the whole of the stockholders as a corporation. It was the assurance given me, that the Board of Directors were determined that the location should be decided upon these principles, that induced me to accept at their hands the appointment of Chief Engineer of the Company.

The citizens of Pittsburg, the citizens of Philadelphia, and the great body of the people of Pennsylvania, have a vast interest in securing the the best railroad route westward from Pittsburg. It may be said that it is desirable to have more than one such road; but if so, how important it is that the best and most profitable should be made first, and that there should be a concentration of effort upon it until it is accomplished. This is especially desirable when we consider the difficulty of raising capital for such enterprises. Local interests on other lines may controvert this doctrine, but it commends itself to the common sense of every man who is free from local bias, and who wishes to promote the general interest of the community. Sooner or later the best line will be made, then let it be made first.

When we see the New York and Erie Railroad pushing forward on the north, and the Baltimore and Ohio Railroad on the south of us, and both

companies acting with renewed vigor and redoubled energy; and when we know that the broad plains of Ohio are the battle field upon which the sea-coast cities of the east are to contend for the trade of the west, we must feel that this is no time to sit down supinely, or to content ourselves with talking about the importance of going on with our work. The time for action has come, and that which is needed is such a subscription to the stock of the Ohio and Pennsylvania Railroad Company as will lay a broad and solid foundation on which the superstructure of the enterprise may safely be erected.

The rapidity with which commercial changes are effected is one of their most remarkable characteristics. In less than twenty years railroads have revolutionized the inland transportation of civilized communities. It is in vain to think of moving on in the old way, when others all around us have called to their aid newer and more active instruments of commercial power. If we do not hasten to avail ourselves of the most recent improvement, we will speedily be distanced in the race of commercial competition. A large town, which has no railroad, will soon cease to have many visiters.

It is believed to be a fact, that the "*Iron City*," as Pittsburg is often called, is the only one of its size and importance in our country that has no railroad.

It will require the construction of about 75 miles of railroad to connect with the Cleveland road near Mount Union, and when that is accomplished, Pittsburg will have a railroad communication by the the most direct and best route, through the Western Reserve of Ohio, to the important city of Cleveland on Lake Erie, the whole distance being about 135 miles. The line will traverse a very populous country, and will furnish a most important outlet for Pittsburg manufactures.

The distance by railroad from Cleveland, by the way of Pittsburg, to Philadelphia, will be 493 miles; while to New York, by Dunkirk, will be 630 miles, and by Buffalo 665 miles; so that much the shortest route from Cleveland to New York will be through Pittsburg and Philadelphia.

A railroad is in rapid progress of construction from Cleveland to Columbus, by what is called the western route, passing about twelve miles west of Mansfield. Its length is 135 miles, so that the railroad distance from Pittsburg to Cleveland will measure, as nearly as may be, the same as that from Cleveland to Columbus, each being 135 miles, and both together 270 miles.

In this way, as soon as our road is completed to Mount Union, Pittsburg will obtain, by a circuitous route, continuous railroad communications with central, western, and south-western Ohio, and those parts of the country will obtain a connexion with the eastern cities more direct than they can by the Lake route from Cleveland.

It is evident, from this, how greatly Cleveland is interested in the speedy completion of *the direct road* from that city to Pittsburg by the way of Mount Union.

The citizens of Salem are well aware of the great importance of our road to that flourishing town, which their energy has made to grow in spite of the disadvantage of having to haul every thing over common country roads.

That the Ohio and Pennsylvania Railroad, when completed from Pittsburg to Mount Union, will be, if properly conducted and managed, a highly

productive investment, there is no doubt in my mind. It will confer innumerable advantages upon the country through which it will pass, will vivify industry in all its forms, and raise the value of real estate in a remarkable degree.

(To be Continued.)

FOR THE JOURNAL OF THE FRANKLIN INSTITUTE.

Remarks on the Resistance of Posts to Flexure. *By* H. Houpt, *Civ. Eng.*

The ordinary formula for the stiffness of beams, supported at the ends and loaded in the middle, is

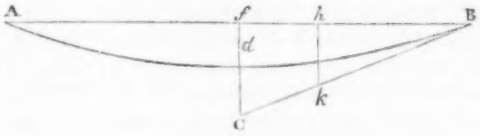
$$w = \frac{b\,d^3}{c\,l^2},$$

in which (w) represents the weight which produces a given deflexion; b=breadth in inches; d=depth in inches, and l=length in feet; c is a constant, to be determined by substituting the values of the other quantities in the equation.

In making experiments to determine the constant from this formula, it is necessary to observe very accurately both the weights and the deflexions produced by them, and then, by means of a proportion, find the value of (w) which will produce the deflexion required to be substituted in the formula.

In reflecting upon the circumstances connected with the flexure of beams, the writer conceived the idea of deducing an expression for the weight which a post would support from the ordinary formula for the stiffness of a horizontal beam, by the following considerations: If a beam is bent by an applied weight, there will be a tendency, from the elasticity of the material, to recover its form when the weight is removed; but if the ends are fastened by being placed between resisting points, so that the piece cannot recover its shape, there must be a horizontal force caused by the reaction of the material, and this force is such, that if the beam were placed in a vertical position and loaded with a weight equal to it, the deflexion should be the same as that of the horizontal beam, and consequently the extreme limit of the resistance of the post to flexure would be determined.

To ascertain the force which is exerted by the reaction of a bent beam in the direction of the chord of the arc.



Let A B represent a beam, supported at the ends and loaded with a weight (w) applied at the middle point.

d = deflexion caused by the applied weight.

B C = tangent of curve at B.

If the weight be removed, the reaction of the beam will cause it to regain its original figure if not resisted by a pressure at the ends. The force of this reaction will be proportional to the degree to which the fibres are strained, and as the strain upon the fibres is nothing at the ends A and B, and increases uniformly to the middle point, the force of reaction will be in the same proportion, and the point of application of the resultant of the whole of the reacting forces will correspond to the centre of gravity of a triangle whose base is B f; it will consequently be at a distance from B $= \frac{2}{3}$ B f.

The effect of this resultant acting at a distance $\frac{2}{3}$ B f, must be the same as the weight $\left(\frac{w}{2}\right)$ acting at a distance B f, and must consequently be in proportion to $\frac{w}{2}$ as 3 : 2. The value of the resultant is therefore $\frac{3\,w}{4}$.

The line of direction of the pressure at B being the tangent B C, the force of reaction at h may be considered as applied at the point k of its line of direction, and as $k\,h$ B and C f B are similar triangles, C f : f B :: $\frac{3}{4}\,w$: horizontal pressure at B $= \frac{3}{4}\,w \times \frac{f\,\mathrm{B}}{f\,\mathrm{C}} = \frac{3}{4}\,w\,\frac{\frac{1}{2}\,l}{2\,d} = \frac{3\,w\,l}{16\,d}$. Representing this force by P we have

$$\mathrm{P} = \frac{3\,w\,l}{16\,d}.$$

As the deflexion of a beam within the elastic limits is always in proportion to the weight, if (w') = the weight that will produce a deflection equal to unity, the deflexion (d) will require a weight $= (d\,w')$, and by substituting this value in the equation, we find

$$\mathrm{P} = \frac{3}{16} \cdot \frac{d\,w'\,l}{d} = \frac{3}{16}\,w'\,l.$$

In this expression (d), which represents the deflexion, has disappeared, and as (w') is a constant quantity for the same beam, representing the weight that produces a deflexion equal to the unit of measure, it follows that P is the same with every weight and every degree of deflexion within the elastic limits.

This result seems at first view to be contrary to fact; it would appear that if the weight is increased, the horizontal strain should be increased in the same proportion; but when it is remembered that the deflexion increases with the weight, and that the former diminishes the value of P in precisely the same proportion that the latter increases it, the difficulty vanishes, and the reason why P should be constant for the same beam becomes obvious.

The practical importance of this result is very great, as it furnishes the means of obtaining a formula which will give at once the extreme limit of the resistance to flexure, or the weight which, applied to a post, will cause it to yield by bending.

As the formulæ used by Tredgold are calculated for a deflexion of $\frac{1}{10}$th

of an inch to one foot, or $\frac{1}{480}$ of the length, the weight which would cause a deflexion of 1 would be $w\left(1 \div \frac{l}{480}\right) = \frac{480\,w}{l}$, and by substituting this value for w' in the equation

$$P = \frac{3}{16} w' l,$$

we find $P = 90\,w = A$.

But from the ordinary formula for the stiffness of a beam supported at the ends we have

$$w = \frac{b\,d^3}{c\,l^2}. \quad \text{Therefore } P = \frac{90\,b\,d^3}{c\,l^2} = B.$$

The expression $P = 90\,w$ shows that the extreme limit of the strength of any post whatever, of any length, breadth, or depth, or of any kind of material, is ninety times the weight which causes a deflexion of $\frac{1}{480}$ of the length.

The second expression, $P = \frac{90\,b\,d^3}{c\,l^2}$, will give the value of P directly, without first knowing the weight required to cause a given deflexion in a horizontally supported beam. In this expression, b = breadth in inches, d = depth or least dimension in inches, l = length in feet, and c = a constant to be determined by experiment for each species of material.

The value of c for white pine is ·01. By substituting this value, we find $P = \frac{9000\,b\,d^3}{l^2}$, a remarkably simple formula, which gives the extreme limit of the resistance to flexure of a white pine post.

The same expression may be used to determine the constants used in the ordinary formula for the stiffness of beams. For this purpose let the equation $P = \frac{90\,b\,d^3}{c\,l^2}$ be transposed, which will give $c = \frac{90\,b\,d^3}{P\,l^2}$. Find P by applying a string to a flexible strip of the material to be experimented upon, in the manner of a cord to an arc, and ascertain the tension on the cord with an accurate spring balance. It will be found that, whether the strip be bent much or little, the tension on the cord, as shown by the spring balance, will be constant, and this tension, in pounds substituted for P, will give the value of c without requiring, as is necessary with other formulæ, an observation of the deflexion.

Experiments made upon these principles with strips of white pine, yellow pine, and white oak, 5 feet long, $1\frac{1}{4}$ inches wide, and $\frac{1}{4}$ inch deep, give the following results:

The observed tensions were—

White Pine,	$7\frac{1}{4}$ lbs.	value of c	= ·0097
Yellow Pine,	$6\frac{1}{2}$ "	" "	= ·0108
White Oak,	$6\frac{3}{4}$ "	" "	= ·0104

As the stiffness is inversely as their constants, it follows that white pine is stiffer than yellow pine or oak. The experiments of Tredgold give similar results.

MECHANICS, PHYSICS, AND CHEMISTRY.

Report on the Gases evolved from Iron Furnaces, with reference to the Theory of the Smelting of Iron. *By* Prof. Bunsen, *of Marburg, Hesse Cassel, and* Dr. Lyon Playfair, *of the Museum of Economic Geology, Department of Her Majesty's Woods and Forests.*

From the Report of the British Association for the Advancement of Science, for 1845.

(Continued from Vol. xvii, page 393.)

The heat lost in a furnace may be easily compared with that actually realized. The following numbers exhibit the quantities of heat (expressed by the unities which we formerly described) generated during the combustion of the gases, and they show at the same time the part played by each constituent in the development of the heat:—

I.		II.	
64·135	Nitrogen yields - - -	00000	
33·758	Carbonic oxide yields - - -	84463	
1·464	Light carburetted hydrogen yields	19719	
0·224	Carbonic acid yields - - -	00000	
0·154	Olefiant gas yields - - -	1898	
0·114	Sulphuretted hydrogen yields - -	510	
0·107	Hydrogen yields - - -	3713	
0·044	Ammonia yields - - - -	267	
100·000	Furnace-gases yield - -	110570	units of heat.

The numbers (II.) representing the units of heat are calculated from the data on the heat of combustion found in the posthumous papers of Dulong.

1 kilogramme, or 15,444 grains of

Carbon burning to CO, heats	15444	grains of water to	1499°C.
" " CO_2	"	"	7371°
Carbonic oxide	"	"	2502°
Hydrogen	"	"	34706°
Light carburetted hydrogen	"	"	13469°
Olefiant gas	"	"	12322°
Sulphuretted hydrogen	"	"	4476° *
Ammonia	"	"	6060° *

The quantity of heat actually generated in the furnace during the escape of the unused 110,570 units of heat may be determined by the amount of nitrogen in the gases, which corresponds to the quantity of the air consumed during their escape. The amount of nitrogen found, viz. 64·126, corresponds to 83·29 of atmospheric air, which is able to effect the conversion of 14·367 carbon into carbonic oxide gas. Proceeding on the

* The ammonia and sulphuretted hydrogen are calculated from their constituents.

experiments of Dulong, the quantity of heat thus liberated will be 21,536°. Thus it follows that a furnace filled with Gasforth coal could realize in the most favorable conditions only 16·30 per cent. of its combustible material. The remainder, 83·70 per cent., escapes as unused but useful combustible matter. The practical use of these gases does not depend merely upon the quantity of heat generated during their combustion, but involves another equally important consideration, viz. the temperature capable of being attained by their use as fuel. This may be determined without any new experiments, by founding the calculation on the composition of the gas, its combustible value, and the capacity for heat of the products generated during combustion.

1 kil. of the gas gives, by its combustion, as we have already seen, 1105·7 units of heat. The products of combustion weigh 2·1385 kil.; and if this last quantity* consisted of water, the heat liberated would raise it to a temperature $\frac{1105{\cdot}7}{2{\cdot}1385}$. Now as the capacity of the heat of water is to that of the products of combustion as 1 : 0·2665, and the elevation of temperature produced in different bodies of equal weight, by equal quantities of heat, is in inverse proportion to their capacity for heat, we obtain, as the expression for the temperature of the mixture of gas burning with air, $\frac{1105{\cdot}7}{2{\cdot}1385 \times 0{\cdot}2665} = 1940°$ C., or 3522° Fahr.

In these calculations we have neglected the influence exerted on the composition of the products of combustion by the gases escaping from the iron ore and limestone. Of course this must differ according to the quantities of materials used in the furnaces, and we therefore select as a basis for the calculation the iron furnaces of Alfreton, belonging to Mr. Oakes, the dimensions of which are given in fig. 6. We proceed on the supposition that the carbonic acid of the limestone and the oxygen of the ore are separated as carbonic acid. The coal used in the furnace was subjected to distillation with the precautions already described, and the composition thus obtained gives us the limits to which the combustible constituent of the gases from the furnace might be deteriorated under the most unfavorable conditions.

		grm.
1.	Weight of the coal used	25·7170
2.	" coke remaining	17·2894
3.	" gaseous and liquid products of distillation	8·4276
4.	" liquid products alone	5·7239
5.	Quantity of tar in the latter	2·4945
6.	" water	3·2294
7.	" chloride of platinum and ammonium from the latter	0·5428
8.	" sulphuretted hydrogen and carbonic acid	0·3574
9.	" sulphuret of lead formed	0·4530
10.	Weight of the condensed hydrocarbons	0·1321

* In this, and also in other similar calculations, the small quantity of sulphuretted hydrogen has been left out of the calculation.

The eudiometric analysis of the uncondensed gases gave the following results:—

	Volume.	Temp.	Pressure.	1 m. at 0° C.
Gas used,	119·9	10° C.	0·4739	54·81
After admission of oxygen,	304·4	10	0·6542	192·11
After the explosion,	189·9	10	0·5335	97·73
After absorption of CO_2,	125·9	9·9	0·4801	58·33
After admission of hydrogen,	350·1	9·9	0·6850	231·44
After explosion,	129·2	10	0·4625	57·64

If we suppose that the very inconsiderable quantity of nitrogen found in the calculation (0·4) was an unavoidable impurity, we obtain, by the use of the formula 1, 2, 3, the following composition for the gas examined:

	According to volume.	According to weight.
Hydrogen	15·41	0·001377
Light carburetted hydrogen	34·63	0·024656
Carbonic oxide	4·76	0·005954
	54·81	0·031987

The 2·2142 carbonic oxide, carburetted hydrogen, and hydrogen, found in the analysis consist therefore of—

Light carburetted hydrogen	1·7067
Carbonic oxide	0·4122
Hydrogen	0·0953
	2·2142

Thus 100 parts of the coal were broken up into the following products:

Carbon	17·289	67·228
Tar	2·494	9·697
Water	3·188	12·397
Carburetted hydrogen	1·707	6·638
Carbonic oxide	0·412	1·602
Carbonic acid	0·293	1·139
Condensed hydrocarbons	0·132	0·513
Sulphuretted hydrogen	0·065	0·253
Hydrogen	0·095	0·370
Ammonia*	0·042	0·163
	25·717	100·000

The 67·228 carbon in the above analysis must escape altogether as carbonic oxide, if a part of it were not converted into carbonic acid at the expense of the oxygen of the iron ore. In order to determine the quantity of carbonic acid thus produced, we must refer to the details of the Alfreton

* The ammonia escaping with the gases out of the condensed alcoholic water is neglected in this calculation.

iron works, in which the following materials are used for the production of 140 lbs. of pig iron:—

420 lbs. calcined iron ore; 390 lbs. coal; 170 lbs. limestone.

According to the above experiment, 100 parts of the coal used give 67·228 of coke; but this quantity of coke does not correspond exactly to that of the carbonic oxide formed during its combustion. It is necessary, before calculating this, to deduct the amount of ashes contained in the coal, and the following analysis of the Furnace-coal of Alfreton gives us the data for the calculation:—

Carbon	74·83
Hydrogen	5·10
Oxygen	9·71
Nitrogen	0·18
Hygrometric water	7·50
Ashes	2·68
	100·00

As the 2·68 of ashes must be deducted from the 67·228 of coke, the latter corresponds to 64·548 of pure carbon. Part of this carbon, however, enters into combination with the iron, and is thus withdrawn from combustion. If we take, according to the analysis of Bromeis,* 3·3 per cent. as the average amount of carbon in cast iron, there must be 1·18 subtracted from the 64·548 of carbon, because the proportion of iron produced to coal used is 35·8 : 100. If we conceive the remainder 63·368 carbon to be burnt with air to carbonic oxide, we obtain as the product of combustion a mixture of—

Nitrogen	285·100
Carbonic oxide	147·858

Of this 147·858 carbonic oxide, part is converted into carbonic acid at the expense of the oxygen in the iron ore. The quantity of cast iron produced from 100 of coal is 35·8, and corresponds to 34·62 of pure iron, for the reduction of which 14·83 oxygen must have been given over to the carbonic oxide gas. By this means 25·952 of the latter would be converted into 40·782 of carbonic acid. The quantity of limestone added to 100 of coal is 43·59. This limestone consists, according to our analysis, of—

Lime	54·4
Carbonic acid	42·9
Magnesia	0·6
Alumina	0·8
Moisture and loss	1·3
	100·0

We must therefore introduce into the calculation, that 18·7 of carbonic acid are evolved from the limestone for every 100 parts of coal. By noticing all these observations the result is obtained, that 100 parts of coal thrown into the mouth of the furnace is reduced to 67·228 coke, by the

* Bromeis, Liebig's Ann. der Chem. B. xliii. S. 243.

loss of gaseous matter, and that this quantity, by passing into combustion when it has descended to the tuyère, produces a gas which, mixed with the nitrogen of the air and the carbonic acid from the limestone, passes back to the mouth of the furnace in the form of a gas consisting of—

Nitrogen - - - - -	282·860
Carbonic acid - - - -	59·482
Carbonic oxide - - - -	121·906
	464·248

If this quantity be added to the products of distillation of 100 parts of coal, the following composition is obtained for the gases escaping from the furnace:—

	I. According to weight.	II. According to volume.
Nitrogen - - - - -	59·559	60·907
Carbonic acid - - - -	12·765	8·370
Carbonic oxide - - -	26·006	26·846
Light carburetted hydrogen -	1·397	2·536
Hydrogen - - - -	0·078	1·126
Condensed hydrocarbons -	0·108	0·112
Sulphuretted hydrogen -	0·053	0·045
Ammonia - - - - -	0·034	0·058
	100·000	100·000

From the numbers given in I. we may compare the proportion of the heat realized in the furnace during the process, with that which escapes in the form of useful combustible matter.

These are generated by the combustion of—

59·559	Nitrogen - - - - - - -	0000
12·765	Carbonic acid - - - - - -	0000
26·006	Carbonic oxide - - - - - -	65067
1·397	Light carburetted hydrogen - - -	18826
0·078	Hydrogen - - - - - -	2704
0·108	Olefiant gas - - - - - -	1331
0·053	Sulphuretted hydrogen - - -	238
0·034	Ammonia - - - - - - -	208
100·000		88374

And therefore out of 100 of the gases, 88,374 units of heat are generated.

The units of heat, 88,374, may be considered as the measure of the quantities of heat capable of being realized by the combustion of the furnace-gases. In order to find the proportion of the fuel actually realized in the furnace to that lost, we have only to calculate the units of heat produced in the furnace itself during the development of 100 parts of the furnace-gases. The only source of heat in the furnace is the oxidation of carbon, and this oxidation is effected at the cost of the air introduced by the blast, and that of the oxygen contained in the oxide of iron. Let us now consider the influence on the units of heat occasioned by the combustion of the carbonic oxide at the expense of oxygen in the oxide of

iron. From the posthumous results of Dulong on the heat of combustion, it follows that the quantities of heat evolved by the combustion of 1 lit. (61·028 cubic inches) of oxygen with iron or with carbonic oxide is almost quite equal. The first gives 6216 and the latter 6260 units of heat. The trifling difference between these numbers is quite within the limits of error of observation, and therefore we may draw the conclusion, as Ebelmen has already done, that the reduction of the oxide of iron is without influence upon the development of heat in the furnace; for in the reduction of the oxide of iron at the cost of the carbonic oxide a thermo-neutrality takes place. Hence the combustion of the oxygen of the air is the only source of heat in the furnace. It suffices to determine the amount of oxygen which has accompanied the 59·559 nitrogen into the furnace in the form of atmospheric air, in order to fix the amount of heat generated. The carbonic oxide formed by the combustion of this oxygen is the only source of heat realized in the furnace, and corresponds, as will be seen in the following calculation, to 20,001. For every 20,001 units of heat realized in the furnace, 88,374 are lost by the gases which escape.

Hence follows the remarkable conclusion, that in the furnaces of Alfreton not less than 81·54 per cent. of the fuel is lost in the form of combustible matter still fit for use, and that only 18·46 per cent. of the whole fuel is realized in carrying out the processes in the furnace.

The maximum temperature which might be obtained by the combustion of the gases may easily be deduced by the following considerations. 1 kil. (15,444 grains) of the gas burned with atmospheric air gives 1·9338 kil. products of combustion, of the following composition and specific heat:—

Nitrogen - - - - -	68·016	0·1859
Carbonic acid - - - - -	29·896	0·0661
Aqueous vapor - - - -	2·088	0.0176
	100·000	0·2696

If we divide the units of heat, viz. 883·74, arising from the combustion of 1 kil. of the gases, by the number resulting when the quantity of the products of combustion is multiplied by their specific heat, ($1·9338 \times 0·2696$,) we obtain for the temperature of the flame 1695°·2 C., or 3083° Fahr. It is obvious that the gases escaping from the furnace must be of still more value as fuel than that expressed by our calculations founded upon their composition when of minimum value. They must be of a higher value, from the circumstance that the reaction of the liquid products of distillation on the red-hot coals produces a number of gaseous substances which must necessarily increase their value as fuel. The upper layers of coal, limestone, and iron, being cold, cause a condensation of the water and tar, both of which drop back upon the red-hot coals in the inferior layers, and become partly decomposed into hydrogen and carbonic oxide gas; whilst another part of the tar is broken up into hydrogen, light carburetted hydrogen, and charcoal. The portions escaping this decomposition are condensed anew by the cold layers above, and finally themselves suffer change. For the purpose of determining the influence exerted by this circumstance on the composition of the gases, we have repeated the experiment on the distillation of the coal, reversing, however, the mode of heating the tube;

we began at the front part instead of the closed end of the tube, so that the products of distillation might have to traverse the red-hot coals, and thus suffer a similar process of decomposition to that which they experience in iron furnaces. The ammonia in this experiment was collected in a Liebig's condenser filled with muriatic acid, and the gases were detained in a gasometer filled with boiled water. The determination of the other data necessary for the calculation was done as in the previous experiments, and the following results were obtained:—

Weight of the coal used - - - - - - -	20·4550
" coke remaining - - - - - -	13·6568
" liquid and gaseous products of distillation	6·7982
" liquid products alone - - - - -	3·5389
" chloride of platinum and ammonium obtained	0·7681
" sulphuretted hydrogen and carbonic acid -	0·5159
" sulphuret of lead - - - - -	0·2500
" gases evolved - - - - - -	3·2593

The quantity of gas collected had the following composition:—

IN FIRST EUDIOMETER.

	Volume.	Pressure.	Temp.	1 m. at 0° C.
			°	
Original volume	116·2	0·6321	11·0	70·61
After absorption of HC	111·9	0·6294	10·8	67·75
IN SECOND EUDIOMETER.				
Original volume	108·6	0·4441	11·1	46·35
After admission of O	282·1	0·6152	11·0	166·84
After explosion	193·8	0·5308	11·1	98·86
After absorption of CO_2	159·2	0·5040	10·4	77·30
After admission of H	383·5	0·7080	11·1	260·92
After explosion	75·4	0·4201	11·3	30·42

Hydrogen - - - -	51·32
Light carburetted hydrogen - -	28·28
Carbonic oxide - - -	16·35
Olefiant gas - - - -	4·05
	100·00

The 3·259 grms. of the gases obtained by distillation must therefore be composed as follows:—

Hydrogen - - - -	0·298
Light carburetted hydrogen - -	1·307
Carbonic oxide - - -	1·327
Olefiant gas - - - .	0·327
	3·259

100 parts of the coal distilled in this way gave—

Coke	13·657	65·123
Tar and water	3·480	16·594
Light carburetted hydrogen	1·307	6·233
Carbonic oxide	1·327	6·328
Carbonic acid	0·480	2·289
Olefiant gas	0·327	1·559
Sulphuretted hydrogen	0·036	0·172
Hydrogen	0·298	1·421
Ammonia	0·059	0·281
	20·971	100·000

This result, contrasted with that obtained when the coal was distilled so as to prevent the products of distillation passing over the red-hot coal, enables us to see clearly the influence exerted upon the tar and steam by the glowing fuel. The liquid products of distillation and the coke are diminished in quantity, and in their place we find an increase of carbonic oxide, olefiant gas, and hydrogen, arising from the carbon being oxidized at the expense of water, and from the decomposition of tar at an elevated temperature. Now if we calculate the composition of the furnace-gases from the principles now laid down, we obtain the following result:—

	I. According to weight.	II. According to volume.
Nitrogen	58.218	57·878
Carbonic acid	15·415	9·823
Carbonic oxide	23·956	24·042
Light carburetted hydrogen	1·555	2·743
Hydrogen	0·354	4·972
Olefiant gas	0·389	0·392
Sulphuretted hydrogen	0·043	0·035
Ammonia	0·070	0·115
	100·000	100·000

The proportion of the substances in this mixture of gases may be viewed as the limits to which the quantity of combustible constituents may increase, when formed under the conditions such as those existing in the Alfreton iron works. We observe at the same time, that the increase of combustible materials effected by the reaction of the liquid products of distillation on the red-hot coal, principally depend upon the augmentation of hydrogen and olefiant gas. If we calculate from the above numbers, according to the principles already laid down, the quantity of heat evolved in the furnace by the formation of 100 parts by weight of the gases, and compare it with the heat which might be derived by the combustion of these gases themselves, we obtain the proportion 98,583 : 19,550, a result showing that in the Alfreton furnaces, under favorable circumstances, only 16·55 per cent. of fuel is realized; while 83·45 per cent. is actually lost by escaping in the form of inflammable gases.

1 kil. of the gas burnt with air gives 1·9290 kil. products of combustion, which consist of—

Nitrogen - - - - -	67·33
Carbonic acid - - - - -	29·83
Aqueous vapor - - - -	2·84
	100·00

The specific heat of the products of combustion calculated from this composition corresponds to 0·2740, from which it follows that the temperature of the flame of this gas burned with air would be 1768° C., or 3214° Fahr.

Thus then the temperature of the gases of the Alfreton furnaces is 3214° Fahr., when generated under conditions approaching to the favorable circumstances in the furnaces themselves.

(To be Continued.)

From the Boston Evening Traveler, May 16, 1849.

Report on the Explosion of a Locomotive Engine called the "Piscataqua," on the Eastern Railroad, on Monday the 2d day of April, 1849.

Read before the Boston Society of Civil Engineers, at a meeting held May 10th, 1849.

This engine was at work on a gravel train, and the explosion took place in the deep cut on Breed's Island, about two and a half miles from the depôt at East Boston.

The fireman, David Sullivan, was killed by the accident. John Innis, engineer, slightly injured. Engine entirely destroyed.

Description of the Engine.

This engine was of the class commonly termed 9-ton engines, and was built in Lowell, by the Locks and Canal Company, about ten years ago. It had been in ordinary use since it came upon the road. Two years ago it was entirely repaired, and the top of the fire box strengthened by the addition of heavier bridge bars. At this time, as nearly as your committee can learn, it was put in perfect repair. Since this, it has been repaired from time to time, as other engines are.

The following were the dimensions of the boiler: Waist length 7 feet, diameter 36 inches; tubes, 61 in number, 2 inches in diameter. Water spaces average between tubes $\frac{5}{10}$ths of an inch. Boiler was stayed lengthwise in the usual manner, by 6 long stay tubes, $\frac{3}{4}$-inch round iron. Thickness of the plates forming the waist of the boiler, $\frac{4}{16}$ of an inch; those forming fire box, $\frac{6}{16}$ of an inch thick. The rivetting of the plates, and connexions with the different parts, were in the manner and form commonly in use. It was supplied by two pumps of the common size, two safety valves, loaded by spring balances and levers to a pressure of 90 pounds to an inch when the balance was screwed down to its lowest mark of graduation. In general there was nothing unusual in the construction of the boiler, or in its apparatus for supplying water, all of which your committee believe to have been in good order.

The report of the master machinist in regard to this engine, was as follows:—"This engine was taken into the repair shop during the first week of January last. At that time, a pair of new wheels were put into the truck frame, the valves and valve-seats adjusted, and the working part of the engine examined and put into line; the dome was taken off, and new joints made. There was nothing done to the boiler, as there was no leakage at that time, nor since, except on the night of Tuesday, 27th March, when it came in *with one tube burst*, and I had both ends of that plugged up that night. On that night the safety valve was unscrewed to let off the steam quick. On the next Friday, 30th of March, I found the safety valve screwed clear down, so that the valve could not act without bending the lever. I unscrewed it at that time to the gauge of 90 lbs., and the steam immediately began to escape freely. On Saturday morning, the 31st of March, I went down with this engine to the Cut, to see about a slide of the bank which had come down the night before. It blew off steam freely at this time. I had found the safety valve of the engine screwed down before, and had spoken to the engine man about it when I found it down, and told him that I would not have a valve screwed down at any time, nor under any circumstances; and this is so understood by all. A safety valve screwed down will have the *appearance* of letting off steam gently, as the surfaces do not make a perfect joint after being used some time."

The work and repairs of this engine from the commencement of the year are as follows:—

	No. of miles run.	Cost of repairs.
January - -	1176	$177·58
February - -	1209	21·82
March - -	1275	18·76
Total -	3660	$218·16

Examination of the Engine after the Explosion, made in the yard of the machine shop at East Boston, April 3, 1849, 10 o'clock, A. M.

The wreck of the engine laid in three separate piles, where it was unloaded from the cars, having been removed from the place where it exploded.

The fire box and part of the lower plates of the waist laid in one parcel; the smoke arch and stack in another. The waist was torn entirely off from the smoke arch, at the angle. The pipes connected with it appeared to have been cut off with an axe, to clear away the wreck of the machine.

The fracture of the iron appeared dark in all parts. Three of the stay bolts were broken off close to the plate—fracture bright; (we learned that they were broken off after the explosion;) and three appeared to have been drawn out, the thread of the screw being torn off. The parts of the cylinders attached to this part of the engine were broken and twirled.

The waist was torn from the fire box at the angle, for about two-thirds of the circumference, the part attached being on the lower side, and was composed of the lower range of plates forming the bottom of the boiler. This was fractured and bent. It showed also some fractures which were evidently made by the falling of the engine after the explosion, being

punched through from without. The fracture round the joining of the waist to the fire box was dark, as at the other end of the boiler; the fractures from without, above mentioned, were bright.

The crown of the fire box was stayed by a large bar, 2½ inches square, in the middle. Four smaller ones, two on each side, were bent down, but not factured.

Some of the small stay bolts connecting the forward plate of the fire box near the waist, were started off. The tubes were all taken away from the end of the boiler when it was removed. They had apparently been lengthened out at some time, the joining of the ends being about six inches from this tube plate, and the short ends remaining in the plate. The joints were lapped and brazed. Of the 61 tubes, in 57 of them the brazing appeared to have been melted, and the laps drawn apart. The other four were not melted apart, but showed the action of the fire, and had apparently been broken off after the explosion. The action of the fire could be seen in all the tubes, through a length of 18 inches from the tube-sheet, and no farther, the remainder of the length being coated with carbon, and the outside showing conclusively that they had been covered with water.

The appearance of these tubes, where they had been heated, was different from those in the "Taghconic," (the engine which exploded on the Providence Railroad,) in the absence of the lustrous scaled appearance which indicates the sudden application of water to heated copper.

The carbon was burned off from the inside of the furnace, and it appeared to have been heated, possibly by the fire remaining in the furnace after the explosion. The whole of the boiler appeared on this examination to have been unusually free from the collection of sediment commonly found in steam boilers in use on railroads.

In the third parcel were the remains of the working parts of the engine, the wheels, frame, and the top sheets of the boiler, in which the dome and safety valves were inserted.

The working parts of the engine were broken and twisted, and were in one mangled heap of fragments. The crank shaft broken at one of the journals, and in the wheel, which was of cast iron, every spoke was broken out. The part of the top plates of the boiler above mentioned, and which held the seats of both safety valves, consisted of the middle sheet nearly entire, and part of two others torn diagonally across. The fracture generally was of the same color as that at the parts before described (dark), and had the same appearance that it would have had if it had been heated and allowed to cool. The fracture followed sometimes the line of rivets, and sometimes across the sheet as before mentioned. The dome had been punched or cut, as it were, out of the plate in which it was inserted.

The fracture, not following the rivets, but following close to the cast iron flanch, had a bright appearance; but as it was thrown into the earth and covered with a wet clay, it may have received its bright appearance from this cause. The frame of the engine was much broken and twisted, and generally, with the exception of the fire box and smoke arch, and the cylinders contained in it, the engine was torn entirely to pieces.

The appearance of the boiler immediately after the explosion, before it was removed, taken from the statement of Mr. Farley, is as follows:

The engine, after the boiler burst, was laying parallel with the track

about eight inches to the right of the rails, looking towards Boston; the tender was on the track, not injured; the waist of the boiler was gone from each end, except the bottom sheet, which was connected with the fire box by about 12 inches, leaving the tubes exposed to view. They were all in their places, except some five or six on the left side, which were found on that side. The fire box rested on the sleepers. The crank shaft broken at one end, and the spokes all broken out of the other wheel.

The four inside frames broken apart in the middle, and the outside framing bent out sideways. The smoke arch remained on the frame.—The sparker was about twenty feet distant, directly ahead. Three of the long stay bolts remained in their places, and three pulled out of the forward tube sheet and bent out sideways. The crown sheet of the fire box was bent down about one-half of an inch.

There was but little fire in the furnace when we got to the engine; not enough to cover the grate. This was sometime after the explosion. The fireman who was killed was found forward of the left hand driver, with his legs hanging over the frame, his face upward, and the back part of his head broken in.

Some of the heaviest parts of the engine were thrown a great distance by the explosion. The dome was thrown 375 feet; the boiler sheet 344 feet; and the bell 975 feet. The "cut" is deep, and the height where the dome was thrown is nearly 60 feet above the level of the rails. The hill falls off to the point where the bell was found.

Coroner's Inquest.

The evidence before the coroner's inquest was substantially as follows:

John Innis being sworn, testified as follows:—Have been running an engine on the Eastern Railroad two years. Am an engineer. I commenced running, about a week ago, the engine called "Piscataqua."—Started about 9½ this A. M. for Breed's Island; placed our cars and remained about 20 minutes to fill the cars with gravel. Told David Sullivan to fill the furnace with wood. Afterward stood by the side a few moments; then went and got upon the right hand side in my usual place when running. Then the said Sullivan remarked that there would soon be steam enough, when he stooped down and opened the furnace door and the boiler exploded. I had one foot on the tender, and the other on the engine platform. When I recovered, found Sullivan on the left side between the engine wheel and tender. Not sensible wholly. Heard Gandall say it was Sullivan. Was somewhat injured by the explosion. Sullivan was fireman at the time of the explosion. Had plenty of water in the boiler. Think the boiler to have been bad. The boiler was about 10 years old. Do not think it would have exploded unless there was some defect in it. Know of no cause for the explosion at this time more than at any other time. Was in the employ of the Eastern Railroad Company, both the engineer and myself; but if there was any defect in the engine, could not have known the fact. The explosion took place about 2½ miles from the depôt.

Samuel Gandall being sworn, testified as follows: Am conductor of the gravel train in the employ of the Eastern Railroad Company. Knew D. Sullivan. He was fireman. Was present, his back turned towards the

engine at the time of the explosion. Saw nothing till I heard the explosion. Found Sullivan hanging by the legs on fragments, back downwards. Was the first to take hold of him. Considered him dead. No signs of life. Carried him out from the rubbish and laid him on the ground. Have known the engine nine or ten years. Known Sullivan two or three years. Should think him about 35 years old. Know of no reason why the accident should have happened to-day more than any other day.

Daniel Crowley being sworn, testified as follows: Have a contract with the Eastern Railroad to fill in gravel at East Boston. * * * Went in the first train. * * * Asked the engineer if he had plenty of water; he said he had. * * * Know of no reason for explosion unless from some defect in the boiler.

Dennis Nolan testified that he filled the boiler at 5½ A. M.—probably 4½ A. M. Saw a large quantity of water from the engine and tender at the time of the explosion.

From inquiries made at the station at East Boston, we ascertained that this engine was filled up and fired early by the watchman; that the tank was filled in the tender at 6½ A. M., containing about 500 gallons. This supply of water has commonly served to run four trips at the same work, or to run 21 miles with an ordinary load—only one-half of which work had been done at the time of the explosion.

Remarks and Conclusions.

Having stated the facts in this case as far as they have come to the knowledge of your committee, they submit the following remarks and conclusions for your consideration:—

The most remarkable fact is, that the engine exploded while at rest—no aperture open to agitate the water, nor pump at work injecting cold water, nor indication from the safety valves that the boiler was unduly loaded with steam. In most recorded cases of explosion, the accident occurred while the engine was in motion, or just started in motion. The appearance of the tubes and the testimony of the witnesses prove that the boiler was sufficiently supplied with water.

After a careful examination, we are of opinion that the explosion was not to be attributed to the weakness of any part of the boiler; but the effect was distributed generally over the whole waist; and that the dark color of the fracture was occasioned from oxidation produced by the heat of the contained steam.* All the parts fractured after the explosion were bright.

It is evident that the pressure of the contained steam was greater than the resistance of the boiler, and your committee are of opinion that the iron of which this boiler was constructed was as good as the average of iron in old boilers.

Taking the average strength of old boiler iron, as stated in the report of the Committee of the Franklin Institute, Vol. xx, page 107, at 50,000 lbs., and the formula $x = \frac{2Pt}{D}$, x representing the pressure in pounds per square

* The discoloration of the surface of iron by different degrees of heat, taken from Rees' Encyclopedia, Fahrenheit's scale—article, Cutlery: 430°, slight color, inclining to yellow; 450°, pale straw color; 470°, yellow; 490°, brown; 510°, brown, with purple spots; 550°, bright blue.

inch sufficient to burst the boiler; P strength of the iron = 50,000 lbs.; *t* the thickness = 0·24 inch; D the diameter of the boiler = 36 inches; and we have x = 666 lbs. per square inch; but as the method of constructing the boilers with rivets reduces this strength, we allow for the reduction, which gives the result of 456 lbs. per square inch, for the actual resistance of the boiler.

Your committee are well aware of the difficulty of arriving at an exact conclusion as to the value of this resistance from this data, as there may have been some parts of the boiler weaker than the strength given by the formula; and were there not other circumstances beside the simple explosion to guide them, they might have doubted that there was so great a pressure of steam. But the fact that, after diligent examination, no parts of the boiler were found to indicate weakness or wearing away of the plates more than has been allowed for in the formula; the discolored appearance of the fracture, indicating a heat not less than 400° Fahrenheit; the heated appearance of the plates themselves, the great distance to which some of the parts were thrown—all indicate a great and undue pressure of steam in this boiler.

We therefore conclude, that at the time the explosion took place, this boiler was subjected to an internal pressure of steam of not much if any less than 450 lbs. to the square inch, and a temperature of 457°; and that this extraordinary pressure was occasioned by an accumulation of steam, in consequence of the safety valves being hindered in their free action.

Whether this obstruction was occasioned by carelessness, or by some defect in the construction of the balances, your committee are unable to state, as they had no evidence which could be conclusive in the matter. But from comparison with other balances, said to have been similar, it was evident that a very little carelessness in screwing down the lever would render the safety valve useless; and this carelessness or inadvertency, your committee are of opinion, was the cause of this explosion. They would therefore suggest the adoption of the practical rule, that when the safety valves are loaded by means of a lever and spring balance, they should be so constructed as to render it impossible to screw down the balance beyond the limit of pressure fixed by the builder or the superintendent of the engines.

WM. P. PARROTT,
SIMEON BORDEN, } *Committee.*

TRANSLATED FOR THE JOURNAL OF THE FRANKLIN INSTITUTE.

Historical Anecdote of Robert Fulton. By M. ANDRE MICHAUX.

Communicated to the Society for the Encouragement of National Industry, by M. De Lasteyrie, at their meeting of February 2d, 1849.

[*Note.*—M. Michaux is the distinguished botanist sent to this country by the French Government, whose work upon the Forest Trees of America is still the standard work upon that subject.—*Ed. Journ. Fr. Inst.*]

"The friends of science and the arts take always a lively interest in inquiring into and learning of even the least circumstances connected with

great discoveries, especially with those which have exercised a remarkable influence upon the prosperity of nations generally.

"The employment of steam, applied first in manufactures, afterwards for the navigation of rivers, then upon the ocean, and finally upon railroads, may be considered as one of the most remarkable events in the nineteenth century.

"I propose to state one of the facts relative to this application, undertaken with the most entire success for the navigation of large rivers by Mr. Robert Fulton, which has most probably not been inserted in his biographical notice.

"Before the year 1806 I had already made two excursions to the United States of North America. On my return to France from my second voyage, I published an account of it under the title *Voyage à l'ouest des Monts Alleghanys, &c.* In 1806, I undertook a third under the auspices of M. le Duc de Gaëte, then Minister of Finance.

"In this last journey, I was instructed to visit all the forests which then covered this part of North America. After having, with this intention, traversed in all directions the Southern, Central, and Western States, I directed my course to the Eastern. In this latter excursion I was accompanied by one of my friends, a French officer, M. Parmentier, a native of l'Orient, who had served in the army of General Moreau, to whom he was greatly attached.

"When we arrived at Burlington, on Lake Champlain, I determined not to prosecute my researches any farther, but to return to New York. We started, in consequence, in a pirogue for Saratoga, where we arrived three days after our departure from Burlington. From this town we went by land to Albany, situated on the North River, and distant about 160 miles from New York. The relations, commercial and other, of all kinds, between these cities are very many and very frequent. At this time decked sailing vessels arrived and departed every day with twenty-five or thirty passengers. The passage generally took thirty-six or forty-eight hours, according as the wind or tide were more or less favorable.

"We had been three days at Albany, when the arrival from New York of a vessel propelled by steam was announced. This boat, which was decked, was about 25 metres (82 feet) long, and was commanded by the inventor, Mr. Robert Fulton. Many of the inhabitants of the city and strangers who were there at the time went to visit it; every one made his remarks upon the advantages consequent upon this new means of navigation, but also upon the serious accidents which might result from the explosion of the boiler.

"The vessel was lying alongside the wharf; a placard announced its return to New York for the next day but one, the 20th August, and that it would take passengers at the same price as the sailing vessels,—three dollars.

"So great was the fear of the explosion of the boiler, that no one except my companion and myself dared to take passage in it for New York.

"We quitted Albany on the 20th August, in the presence of a great number of spectators.

"Chancellor Livingston, whom we supposed to be one of the promoters of this new way of navigating rivers, was the only stranger with us; he

quitted the boat in the afternoon to go to his country residence, which was upon the left bank of the river.

"From every point on the river whence the boat, announced by the smoke of its chimney, could be seen, we saw the inhabitants collect; they waved their handkerchiefs and hurraed for Fulton, whose passage they had probably noticed as he ascended the river.

"We arrived the next day between one and two o'clock at New York. We separated from Mr. Fulton after paying him the price of our passages.

"The day after our departure from Albany, and a few minutes after Chancellor Livingston had quitted us, Mr. Fulton expressed his surprise that, notwithstanding the number of persons who were going to New York, only two Frenchmen had had the courage to embark with him. In the course of the conversation, I informed him that M. Chaptal, then Minister of the Interior, had instructed me to examine the forests of this part of North America, and especially to study the trees which compose them, in reference to their employment in the useful arts. I told him that, on my return to Europe, I intended to publish a work upon this subject with plates. He approved of my project, adding that, in America, such a publication would be successful on account of its usefulness; that it would do me honor, and would be profitable to me; which has proved to be true.

"My companion and myself could not too warmly congratulate Mr. Fulton upon the complete success, not of his discovery, but of the application of steam to act thus powerfully against the wind and tide. With great kindness, he explained to us the mechanism of the machine, and how the impulse was given; he dwelt principally upon the incalculable advantages of this means for ascending the great rivers of the interior, particularly the Mississippi, navigable for a distance of more than 800 leagues, and of which the current has an extreme force and velocity.

"Upon my observing to him the difficulty which he would have to procure coal to heat his boiler, he said that he would replace it by wood; that the banks of the river were almost uninterruptedly covered with thick forests; that, in truth, this mode of heating would have the inconvenience of multiplying the stoppages, and increasing their length by the time necessary to fell the trees, cut them into proper lengths, and carry them on board of the vessel, etc. Do not, said I to him, let that disturb you at all. Last year, I crossed in several points the western parts of Virginia and Pennsylvania, situated between the Allegheny Mountains and the Ohio. The numerous and deep ravines cut by the streams which empty into that river exposed beds of bituminous coal, which lie at a depth of only two or three feet. This combustible is so easily procured that, although the whole country is covered with primitive forests, and consequently wood costs only the trouble of cutting the trees, the inhabitants (then it is true not numerous) found it more easy and less troublesome to go and get coal with a pickaxe and wheelbarrow; in short, that the abundance of this combustible, and the extreme ease of getting it were such, that it could be delivered at New Orleans, although the distance might be estimated at 800 leagues, at 10 francs per quintal. ($2 per cwt.) 'Your information,' said Mr. Fulton, 'is one of the most agreeable facts which I could hear; there can be no doubt of the incalculable advantages of the application of steam navigation to the interior of the United States; you,

gentlemen, are the first persons who have dared to accompany me, and who are witnesses of the complete success obtained.'

"It appears that, at this time, Mr. Robert Fulton did not suspect that steam navigation might be one day applied upon the sea, and for traversing the ocean in much less time than with sailing vessels; he said nothing to us about it. I informed Mr. Fulton that I intended to return to France about the end of that year (1807). He then said that he had but lately returned thence; that, under his deep conviction of the importance of this application of steam to navigation, he had presented himself to the Ministers of the Navy and of War, that they might give him the means of making experiments, and finally to the Academy of Sciences of the Institute; that everywhere he had been well received, but that the first answer to him was always the want of money; that moreover the expansive force of steam was a thing long known, and that, as to the application which he proposed to make of it to navigation, its success was very doubtful, because very probably this force, powerful as it was, would not succeed in overcoming, at certain seasons of the year, the violence of the currents of rivers. This opinion was also expressed in a report made upon the subject to the Academy of Sciences, by the Minister of the Navy, Decrés. Rejected everywhere, Mr. Fulton returned to America. 'During my solicitations of the Ministers,' said he, 'I went to see M. Carnot. If, said he, I had still the honor to be Minister of War, I would not hesitate a moment to give you the means to make your experiment, the success of which is unquestionable, for I understand all the means of its action, and I foresee the immense results for the future. Since you are about to return to France,' added Mr. R. Fulton, 'have the goodness to call upon M. Carnot for me, and tell him that I shall never forget the kind reception which he gave me; tell him of the complete success of my efforts and my perseverance, of which you are the first witnesses; tell him that I shall always feel the deepest regret that France did not profit by my offers for the great enterprize which her government then meditated.'

"If we refer to this epoch, we find that the Emperor had resolved to make a descent upon England, and for that purpose had collected together an immense army at Boulogne, and had, to effect his debarcation, built a great number of vessels of all sizes. If, then, M. Carnot had still been Minister of War, and twenty steamboats had been constructed in a few months by Mr. Fulton, what might we not augur for the success of the enterprize? Then, without question, would France have become the first nation of the globe. Her power would have been lasting, for it would have had for its base the products of her agriculture, and not manufacturing industry, whose prosperity is always subject to events."

Bul. Soc. Enc. Nat. Ind. Sept. 1848.

On the Diurnal Variations of the Magnetic Needle, and the Aurora Borealis.

By M. Auguste de la Rive.

Extract of a Letter to M. Arago. Translated for the Journal of the Franklin Institute, from Annales de Chimie et de Physique, 3me serie, tom. xxv., p. 310.

Permit me to communicate to you, with the request that you will submit it to the Academy of Sciences, an extract from a memoir which I

recently read before our Society of Physics and Natural History, upon the cause of the diurnal variation of the magnetic needle, and of the Aurora Borealis. In proceeding in the reference of these two classes of phenomena to the same cause, I have only followed the route which you yourself have traced; for more than thirty years ago, you, with indefatigable perseverance, established by your numerous observations the remarkable concordance which exists between the appearances of the Aurora Borealis and the disturbances of the magnetic needle.

The following is my theory; you will remark that it rests only upon well established facts, and solidly established principles of physical science. I had already, in 1836, in a notice upon hail, (*Bibliotheque Universelle, nouvelle serie, tom.* III. *p.* 217,) endeavored to prove that the atmospheric electricity owes its origin to the unequal distribution of temperature in the layers of the atmosphere. It is known that in a body of any kind, heated at one of its extremities and cooled at the other, the positive electricity passes from the warm toward the cold part, and the negative in the opposite direction; hence it follows that the lower extremity of an atmospheric column is constantly negative, and the upper end positive. This difference in the opposite electrical states must be greater in proportion as the difference of temperature itself is greater, and consequently more strongly marked in our latitudes in summer than in winter, and in general, more sensible in the equatorial than in the polar regions. It must be remarked that the negative condition of the lower portions of the atmospheric columns must communicate itself to the surface of the earth upon which they rest, while the positive state of the upper ends transmits itself from above downwards, along almost the whole length of each of the columns, according to the facility which the greater or less degree of moisture in the air presents for the propagation of the electricity. An atmospheric column is therefore like a pile of high tension, on account of the imperfect conductability of the elements of which it is composed; a pile, the negative pole of which, in constant and direct communication with the terrestrial globe, discharges itself into it, while it charges itself with electricity from its positive pole, which is distributed with an intensity decreasing as we depart from that pole; which explains why it is that the positive electricity increases in proportion as we rise in the atmosphere.

The causes which determine the accumulation of negative electricity at the surface of the earth, and that of the positive electricity in the upper regions of the atmosphere, act continuously; an unlimited tension of the two opposite electrical conditions ought to result, were it not that, when they reach a certain degree of energy, they neutralize each other by the effect of different circumstances. In other words, when they reach a certain limit of tension, which varies with the state of the atmosphere, and of the surface of the soil, the two electricities cannot pass this, and they recompose or neutralize each other beyond this limit. This neutralization is effected in two ways: in a constant or normal manner, and in an irregular or accidental manner.

This second mode presents itself under very varied forms; sometimes it is the mere moisture of the air, or better still, the rain or snow, which re-establish the electrical equilibrium between the earth and the atmosphere; in some cases tornadoes shew, in an energetic form, the mutual

action of the two electricities tending to unite together. Sometimes the winds, by mixing the air in contact with the surface of the earth, and like it negative, with the positive air of the higher regions, give rise to heat lightnings or to storms when the formation of clouds and condensation of watery vapors from the effect of the moisture, and different temperatures of the strata of air which are mixed together, take place at the same time.

The attraction of the clouds by the mountains, and the luminous phenomena which shew themselves upon elevated points are also due to the same cause. But I will not dwell any longer upon all these natural and easily understood consequences of the theory which I am developing; I will confine myself to a single remark, that is, that in observations on the atmospheric electricity, we must take into consideration that the intensity of the electric signs perceived is not always a proof of the intensity of the electricity itself, for the moisture of the atmosphere, by favoring the propagation of the electricity of the upper strata, may, as we often see in winter, give rise to very energetic electrical manifestations, even when the cause which produces them is not very powerful. We frequently see the reverse in summer.

I pass to the regular and normal mode of neutralization of the two electricities. I already hinted at the existence of this mode in my notice of 1836, but I did not indicate it expressly, as I then wanted a datum which Science now possesses, to wit: the perfect conductibility of the globe, which the use of the electric telegraph has made known.

To explain clearly my conception of this mode of neutralization, I suppose the atmosphere divided into annular strata parallel to the equator; the positive electricity accumulated in the outer portion of the stratum, cannot exceed a certain degree of tension without passing through the rarified and much less moist air to the polar regions, where, finding an atmosphere saturated with moisture, it will re-unite easily with the negative electricity accumulated upon the earth. Thus we have the circuit formed; each annular stratum of the atmosphere gives rise to a current, which travels in the upper regions from the upper portion of the stratum towards the pole, re-descends towards the earth through the atmosphere around the pole, and returns by the surface of the globe, from the pole to the lower part of the stratum from which it started. These currents will be, therefore, more numerous and more concentrated in proportion as we approach nearer to the pole; and as they move always in the same direction: that is, from south to north in the upper part of the atmosphere, and from north to south at the surface of the earth, their effect will become more sensible as we leave the equator and approach the pole. But as the currents produced by the equatorial strata are individually stronger than those which come from strata more towards the north, the difference, although real, will nevertheless be less than we might at first believe. What takes place in our northern hemisphere must occur similarly in the southern hemisphere; the currents pass also from the equator to the pole in the upper regions of the air, and from the pole to the equator upon the surface of the earth. Consequently for an observer going from the north to the south pole, the current would move in the same direction with him from the north pole to the equator, and in a contrary direction from the equator to the south pole. I speak here of the current which moves along the surface of the earth. I must

also remark, that the limit which separates the regions occupied by each of these two great currents is not, properly speaking, the equator, for it must be variable; it is, according to the theory which I am developing, that one of the parallels between the tropics which has the sun in its zenith, consequently it changes every day.

It is now easy to understand the cause of the diurnal variations of the magnetic needle. Conformably to the laws established by Ampere, the current which passes from the north pole to the equator ought to deflect the north pole of the needle to the west; this is what takes place in our hemisphere; and the current which passes from the south pole to the equator ought to deflect the north pole of the needle to the east; this is in fact what takes place in the southern hemisphere. The deviation at the same place ought to be greater in proportion as the difference of temperatures, and consequently of electric conditions, between the lower and upper strata of the atmosphere is greater; thus the deviation increases from the morning until 1h. 30m. P. M.; it is greatest in the months during which the sun is longest above the horizon, and is at its minimum in the winter months. Finally, these diurnal variations increase in amplitude in proportion as we leave the equator and approach the pole, a result still perfectly in accordance with what I have said of the increasing number of the currents towards the polar regions. In these regions, too, the variations may be very irregular, and perhaps null, if the magnetic needle be placed in situations where the electric currents traverse the atmosphere to reach the earth; in fact, a needle thus enveloped in currents on all sides is no longer affected, or at least is no longer affected in a regular manner. This remark may explain certain observations, particularly those made at Port Bowen, which appear to be anomalous.

I have been singularly struck, in examining very closely all the magnetic observations which I could obtain, and especially those of Colonel Sabine, by the remarkable manner in which they accord with the theory. I will cite but a single example: that is the very recent observations made at Saint Helena, which Colonel Sabine has just published. At Saint Helena the diurnal variation takes place towards the west so long as the sun is southward of the isle, towards the east as soon as the sun passes to the northward. In fact, in the first case, as I have remarked above, Saint Helena must be within the region in which the electric currents pass over the surface of the earth from the north pole to the equatorial regions; and in the second case in the region in which these currents go from the south pole to the equator. The hour of maximum diurnal variation is not the same for the island of Saint Helena as in continental countries, because the temperature of the surface of the ocean does not follow the same laws of diurnal variation as the temperature of the surface of the ground. Now the temperature of the lower stratum of the atmosphere must always be the same as that of the sea or land upon which it rests. This same circumstance explains certain apparent anomalies which the diurnal variations present in certain parts of the globe, as, for instance, at the Cape of Good Hope, which is surrounded on all sides by a vast expanse of ocean.

I desire it to be particularly remarked that, in what I have said, I have had reference only to the causes of perturbation of the direction of the magnetic needle, and by no means to the cause of that direction itself: that is,

of terrestrial magnetism, the cause of which I by no means believe to be of the same nature, but in reference to which I do not at present speak. I content myself with considering the terrestrial globe as a large spherical magnet, and I study the external causes which may modify the direction which it, as a magnet, tends to impress upon magnetic needles.

What is the Aurora Borealis upon the theory which I thus propose? It is the luminous effect of the electric currents which pass in the upper regions of the atmosphere towards the north pole; the effect due to the union of certain circumstances which do not always present themselves in the same manner, nor at all seasons of the year. It is now well proven that the aurora borealis is an atmospheric phenomenon, as you long since suggested. The name *magnetic storm*, by which M. Humboldt designates it in his *Cosmos*, in fact suggests the same idea, which, moreover, the interesting details which he gives about this meteor confirm. The observations of Parry, Franklin, and especially the numerous and well made ones of MM. Bravais and Lottin, are also entirely favorable to this opinion, which, moreover, was the result of the observations of M. Biot, at the Shetland Islands.

This point being admitted, the following is the way in which I explain the production of the aurora borealis. When the sun, having passed into the southern hemisphere, no longer heats ours so much, the watery vapor which had accumulated during the summer in this part of the atmosphere begins to condense; the kind of moist cap which envelops the polar regions extends continually more and more, and facilitates the discharge of the electricity accumulated in the upper parts of the air. But in these high latitudes, and especially at this epoch of the year, the watery vapors must generally pass into the state of small particles of ice or snow floating in the air, like those which give rise to halos; they form, as it were, a kind of semi-transparent mist. Now these half frozen fogs conduct the electricity to the surface of the earth near the pole, and are themselves, at the same time, illuminated by these currents or electrical discharges. In fact, all the observers agree in stating that the aurora borealis is always preceded by a mist which rises from the pole, the edges of which, less dense than the rest, are first colored. Thus, also, it is more frequent near the pole in the winter months, and particularly in those during which there is much vapor in the air. In order that it may be visible at great distances from the pole, it is necessary (and it cannot often occur) that these clouds, composed of icy particles, should extend in an almost continuous manner from the polar regions to latitudes well to the southward. It is these same clouds which, when they are partial, which then frequently happens, give rise to halos.

Now the analogy noticed by almost all observers, between the mists which accompany the aurora borealis and those which produce halos, is a circumstance not a little remarkable. It is easy to verify, by direct experiment, the identity between the light of the aurora borealis and that which we obtain in passing a succession of electric discharges through rarefied air containing much moisture, and more particularly through a very thin stratum of snow or frost upon glass. I have satisfied myself that air much rarified, but perfectly dry, gives but feeble flashes, and that, in the experiment of the tube exhausted of air, it is essentially the moisture ad-

hering to the inner walls of the tube which, by conducting the electric discharges, gives rise to the luminous effects. It is evident that the electric discharges transmitted by this kind of net-work of ice, must, when concentrated near the pole, determine there a light much more vivid than that which they develop when they are spread over a greater surface.

But why is it the magnetic and not the terrestrial pole which appears to be the cause of the phenomenon? The following is my answer: Let the pole of a strong electro-magnet be placed under a large surface of mercury; let the surface be made to communicate with the negative pole of a strong pile; let the point of a piece of charcoal communicating with the positive pole be approached to it; immediately the voltaic arc forms, and the mercury is seen to be agitated above the electro-magnet; wherever this is placed, the luminous currents turn around this pole, and from time to time throw out very brilliant rays. There is also, as in the case of the aurora borealis, an obscure part, in the form of a circular point above the pole of the magnet; this peculiar effect ceases, without any interruption of the voltaic light, when the electro-magnet ceases to be magnetized. With a continuous current of ordinary electricity, arriving at the pole of a powerful electro-magnet in rarefied and moist air, luminous effects are obtained which are still more similar in appearance to those of the aurora borealis.

These phenomena are the result of the action of magnets upon currents. Now the same effect must be produced by the magnetic pole of the earth; the neutralization of the two fluids probably takes place over quite a large extent of the polar regions, but the action of the magnetic pole determines the conducting fogs to turn around it, throwing out those brilliant rays, which, by the effect of perspective, appear to us to form the auroral crown. The sulphurous odor and the noise, which it is asserted sometimes accompany the aurora, will not be inexplicable; that odor would be due, like that which accompanies lightning, to that modification which the passage of electric discharges causes in the oxygen of the air, which M. Schönbein has called *ozone;* and as to the noise, it must be analagous to that which is produced, as I have shown, by the voltaic arc, when it is under the influence of a magnet very near it. If it takes place only very rarely in the aurora borealis, it is because it is very seldom that the luminous arc is sufficiently near the earth, and consequently to the pole. But the description of this noise, given by those who have heard it, is perfectly identical with that which I, without suspecting their analogy, gave of the noise which the voltaic arc gives under the action of magnetism.

The magnetic perturbations which constantly accompany the appearance of the aurora borealis are now very easily explained. This accidental recombination of a greater amount of the accumulated electricities must derange the normal action of the regular current; as to the direction of the perturbation, it will depend upon the part of the current which acts upon the needle, and consequently upon circumstances which it is impossible to predict beforehand, since they depend upon the extent of the phenomenon, and the position of the needle in reference to it. In fact, according as the horizontal plane in which the needle moves passes above or below the region in which the greatest activity of the phenomenon takes place, it will be either the current which travels upon the earth, or that in the air, (currents which pass in opposite directions,) which will act upon the needle;

even during the continuance of the same aurora, it may be at one time one, and at another time the other, of these currents which act. The variable directions in which the needle is deflected during an aurora borealis, accord very well with this explanation, at least so far as I have been able to judge from the different observations reported in the *Annales de Chimie*, and in different scientific travels. The remarkable effect which M. Matteucci has observed in the apparatus of the electric telegraph between Ravenna and Piso, during the magnificent aurora of the 17th November last, shews clearly the existence of a current circulating upon the surface of the earth, and which, rising by the telegraph wire, passed partly by this better conductor. The sounds which are given in certain meteorological circumstances by long iron wires stretched in a north and south direction, are clear evidence that they are traversed by a current which probably arises from those which circulate upon the surface of the earth, from north to south in our hemisphere. It would be very interesting to take advantage of telegraph wires having a direction more or less coincident with that of the declination of the needle, for the purpose of making, when they are not in use for their usual purposes, some observations to detect and measure the electric currents which probably traverse them; which would be easily done by completing the communication of these wires with the ground at one of their extremities, by means of a multiplying galvanometer. The comparison of results thus obtained, with those of simultaneous observations of the diurnal variations of the magnetic needle, would certainly present much interest, and might lead to meteorological conclusions of a remarkable kind.

I cannot terminate this extract without remarking that M. Arago had already, in 1820, a short time after the discovery of Œrsted, indicated the possibility of acting upon the voltaic arc by his magnet, and the analogy which might result between this phenomenon and that of the aurora borealis.

Translated for the Journal of the Franklin Institute.

Apparatus to preserve the Electric Light constant.

At the sitting of the Academy of Sciences of Paris, held on the 18th January, 1849, M. L. Foucault reminded the Academy that five years ago he had, together with M. Donnè, an apparatus in which the electric light was used in obtaining upon a screen a magnified image comparable with that given by the solar microscope itself. But in this instrument there was a great inconvenience arising from the necessity of continually watching and adjusting the charcoal points. This apparatus he has since modified so as not only to keep the poles, by a spontaneous action, at the same distance apart, but also to keep the radiant point immoveable. These results he obtains by the following arrangements: The two points are pressed together by springs, but cannot move in that direction without setting in motion a train of wheels, the last of which is controlled by an escapement. The current of the apparatus passes around an electro-magnet, the energy of which of course depends upon the intensity of the current; this electro-magnet acts upon a piece of soft iron, which is pressed in the opposite di-

rection by a spring. Upon this soft iron is mounted the detent which checks the train of wheels before mentioned, and the direction of the movement is such, that when the current becomes stronger it presses upon the wheel-work, and when it becomes weaker, releases it. And as the current becomes stronger or weaker, according as the poles approximate to or recede from each other, it will be seen that the poles become free to approach each other as soon as their distance apart increases, but that they can never come in contact, because the increasing strength of the magnetism developed by their approach, presents an insurmountable obstacle, which removes itself as soon as the interpolar distance has again increased.

The approach of the charcoal points is therefore intermittent; but when the apparatus is in good adjustment, the periods of rest and movement succeed each other so rapidly as to be equivalent to a continuous progression.

M. Foucault states that he has been in possession of this apparatus for eleven months. He notices the very similar invention of Mr. Staite, and remarks that he does not wish to contest the merit of that gentleman's invention, but that he asks for a committee of the Academy to examine the condition of his apparatus, and the proof which he will adduce that the idea also originated with him, and was not copied from Mr. Staite. He also promises to show the committee a Bunsen (Carbon) battery, which can be put in action or taken apart in less than five minutes.

Upon this application the Academy appointed MM. Dumas and Regnault a committee, who at the next meeting (22d January,) reported that they had examined the apparatus of M. Foucault, and found it to work successfully, and that they are convinced, from the state of the apparatus, as well as from the certificates of the instrument makers, and the testimony of persons honorably known to the Academy, "that the means invented by Foucault originated with him, and were independent of those which Mr. Staite had also invented for the same purpose." They also reported that they had seen the galvanic battery so arranged as to be taken to pieces and put in action again in a few minutes.

Comptes Rendus de l'Academie des Sciences.

At the meeting of the 29th January, M. Gaigneau remarked that without suspecting the good faith of M. Foucault, he desired to inform the Academy that on the 14th of January, 1848, he had taken out, in the name of Mr. Wm. Petrie, of London, a patent for an apparatus which fulfilled the same conditions, in the same manner; and that the patent was not confined to this, but contained besides a method of producing an intermitting light for light houses, in which the period of intermittence could be regulated beforehand. He asked for a committee to report upon Mr. Petrie's discovery.

Translated for the Journal of the Franklin Institute.

Description of some Minerals from Brazil.

At the meeting of the Paris Academy of Sciences of 5th March, 1849, M. Dufrenoy exhibited to the Academy a specimen of a mineral from Brazil, which appears, as M. Elie de Beaumont remarked, to be to the diamond what emory is to corundrim. These specimens occurred among

some recently furnished to the School of Mines, by M. Hoffman, a dealer in minerals; they came from Brazil, and were said to be hard enough to polish the diamond. In fact, their hardness was found to exceed that of the topaz. The singularity of this character induced M. Dufrenoy, Director of the School, to cause them to be analysed by M. Rivot, the head of the assay department of the School. The result of his examination was as follows:—

M. Rivot had at his disposition a large fragment weighing 65·76 grammes, (about 1000 grains,) and several small pieces weighing rather less than ½ gramme, (7·5 grains;) these last were alone analyzed. The larger piece seemed to have come from the same alluvium formation in which the diamonds of Brazil are found. Its edges were broken down by long friction, but it had not the appearance of a river pebble. It was of a slightly brownish black, dull; under the glass it appeared full of small cavities, separated by very small irregular lamellæ, slightly translucent and iridescent in the sun's light. The brown color was very unequally distributed throughout the specimen. Upon the face the cavities were arranged in lines which gave a fibrous appearance to it, as in the obsidian. It cuts glass easily, and scratches quartz and topaz. Its density, taken in distilled water at 12°, (53·6° Fah.,) was 3·012; the small pieces submitted to analysis presented the same aspect and the same hardness; their densities, taken at the same temperature, were found to be 3·141, 3·416, 3·255.

By a long calcination at a bright red heat, in a luted crucible, the specimens were not altered; they kept their aspect, hardness, and weight.—They contained, therefore, no matter volatile at that temperature out of contact of air.

They were analyzed by burning them in porcelain tubes, in a current of pure oxygen, according to the method used by M. Dumas. In the analysis of the first specimen, but a single potash tube was used, and a portion of the carbonic acid was consequently lost; in the other analysis this accident was guarded against by the addition of a second potash tube.

The following were the results of the analysis:—

	Ashes.	Carbon.	Sum.
1st specimen	2·03	96·84	98·87
2d "	0·24	99·73	99·97
3d "	0·27	99·10	99·37

The ashes were yellowish, and, in the first specimen, kept the form of the diamond. Examined under the microscope, they appeared to be composed of ferruginous clay and little transparent crystals, the form of which could not be determined. L'Institut, 7th March, 1849.

The above evidently describes the same substance as that exhibited by Dr. Patterson at a meeting of the American Philosophical Society, on the 18th August, 1848, and thus referred to in their Proceedings. (*Vol.* v., *No.* 41, *p.* 33.)

"Dr. Patterson laid before the Society specimens of two minerals from the diamond mines of Brazil, received through Mr. Ernest Pailhet, a merchant of Paris, now in Philadelphia, by whom they were first introduced into commerce.

"One of these minerals occurs in irregular black lumps of considerable size, and is found in the diamond grounds one or two feet below the surface. It is considered a certain indication

of the presence of diamonds, which, indeed, are sometimes found inside of its masses. Its structure is perfectly vitreous, and it appears to be a pure obsidian.

"The other, called 'Diamond Carbon,' or 'Black Diamond,' is found in the same locality. It cuts all other minerals, including the diamond itself, upon which it acts with as much rapidity as the diamond dust. The specific gravity of the smaller piece is 3·01. These minerals first attracted attention at the diamond mines, about six years ago. The 'Diamond Carbon' is sold here at 75 cents per carat of 3 1-6 grains troy, being about 25 cents per grain, or about six times the value of gold.

"Dr. P. conceives that the 'Diamond Carbon' will be found exceedingly useful in the arts, being applicable to all purposes for which diamond dust is now used."

Translated for the Journal of the Franklin Institute.

New Preparations for Cleaning Cast and Wrought Iron.

From the Minutes of the Managers of the Soc. for the Encouragement of National Industry.

M. Sorel, after recalling the labors of MM. Thomas and Delisse on the cleaning of metals (*See Jour. Fr. Inst., Vol.* XVI, *3d series, p.* 137,) observed that success in zincing or tinning wrought or cast iron depended, in a great measure, upon the cleaning, especially with cast iron. In fact, it may be conceived that if the acid exposes the carbon of the metal, it becomes impossible to make the tinning adhere. This is the reason why, up to this time, cast iron has not been tinned in the bath, notwithstanding the advantages of being able cheaply to tin cast iron culinary vessels.

M. Sorel has for a long time employed in his establishment for galvanizing iron, acids prepared by means of organic matters, such as, for example, diluted sulphuric acid, which has been used in the purification of lamp oil. This acid contains an oily matter which gives it the property of detaching and dissolving the oxide of iron without attacking the metal.

Finding, however, inconveniences in the employment of organic substances, M. Sorel examined whether, in the mineral kingdom, something better could not be had. He found that certain salts dissolved in acids replaced the organic matters with great advantage. The salts which gave him the best results are those of copper, antimony, and tin. He prefers to use the two former with muriatic acid slightly diluted with water, and the salts of tin with water acidulated with sulphuric acid.

The following are mixtures which he has used successfully:—

First Mixture.—Water acidulated with sulphuric acid, so as to mark 10° on the hydrometer at 59° Fah., 96 parts by weight.
Protomuriate of tin, 4 "

Second Mixture.—Add about 4 parts of a salt of copper to the above.

To clean wrought iron, more acid and less of the salts may be added, but for cast iron the modifications must be in the opposite direction. All the salts of copper are nearly equally efficacious.

The salts of tin also give good results with the other acids which are employed in cleaning iron, such as muriatic, but in a less degree than with the sulphuric.

Third Mixture.—Muriatic acid slightly diluted so as to mark about 15°, 98 parts.
Any salt of copper, (acetate, sulphate, nitrate, or chloride,) 2 parts.

These proportions may be modified; the quantity of the salt of copper may be increased, and another salt, such as sulphate of lead, zinc, iron, or others, but slightly soluble in muriatic acid, may be added; the hydrated oxide of iron and pyrolignite of iron answer well.

Hydrochloric acid diluted with water, in which a salt of copper has been dissolved, acquires, in a high degree, the important property of dissolving the oxide of iron, without attacking the metal. This compound has, besides, the advantage of cleaning in a few minutes.

It can be seen when the metal is attacked, 1st, by the disengagement of bubbles of gas; 2d, by a change in the appearance of the acid, which, from a slightly opaque olive, becomes limpid and blueish; 3d, by the precipitation of copper upon the iron. A little of the copper salt must then be added, which re-establishes it completely.

Bul. Soc. En. Nat. Indus., Dec. 1848.

Method of Soldering Cast Iron with Wrought Iron.

The following process has been recommended for this purpose:—First melt filings of soft cast iron with calcined borax in a crucible; then pulverize the black vitreous substance which is thereby produced, and sprinkle it over the parts which are intended to be united; after which, heat the pieces of cast and wrought iron, and weld them together on an anvil, using only gentle blows. This method is peculiarly applicable for the manufacture of iron articles which are intended to be made red-hot, and are required to be impervious to fluids or liquids; as such a result cannot be obtained by simple fastening.—[*Technologiste.* Lond. Journ. Arts, May, 1849.

Translated for the Journal of the Franklin Institute.

Experiments with the Light of the Voltaic Arc. *By* M. L. Foucault.

After describing his apparatus, (vide supra, p. 46,) M. Foucault thus proceeds: "We thus obtain arcs of all kinds which are persistent, and which can, bythe aid of lenses, be thrown upon a screen to contemplate their physical appearance, or upon a linear diaphragm, for the purpose of analysing them by the prism. A commutator is also used, to invert the direction of the current, for the purpose of shewing better the part of the action due to the positive and negative poles. This study, the end of which cannot yet be seen, has already given me the following results:—

The arc from charcoal points, which is certainly the most easily managed, furnishes by the prismatic analysis the most curious and brilliant appearance. Its spectrum is crossed, as is known, along its whole extent by a multitude of irregularly grouped luminous lines; but among these a double line is remarked, situated on the boundary between the yellow and the orange. This double ray recalling, by its form and position, the line D of the solar spectrum, I was desirous of examining whether it corresponded to it; for want of instruments to measure the angles, I had recourse to a peculiar process.

I projected upon the arc itself an image of the sun formed by a converging lens, which permitted me to observe at once the solar and electric spectra superposed. In this way I satisfied myself that the double bright line of the arc coincides exactly with the double black line of the solar light.

This process of investigation furnished me with the means of several unexpected observations. In the first place, it proved to me the extreme transparence of the arc, which but faintly shadowed the light of the sun. It shewed me that this arc, placed in the path of a beam of solar light, absorbed the rays D, so that this line of the solar spectrum is considerably strengthened when the two spectra are laid exactly over each other. When, on the contrary, they overlap, the line D appears blacker than usual in the solar light, and comes out more brilliant in the electric spectrum, so that we can easily judge of their perfect coincidence. Thus the arc offers to us a medium which itself emits the rays D, but at the same time absorbs them when they come from another source.

To make the experiment in a still more decisive way, I threw upon the arc the reflected image of one of the incandescent points of charcoal, which, like all bodies in ignition, gives no lines, and under these circumstances the line D appeared as in the solar light.

Passing then to the examination of the arcs furnished by other matters, I have almost always found the line D positive and at its place, and I have ascertained that it also coincides exactly with the brilliant line from the flame of a candle.

When the poles employed are of metals which give the ray D but feebly, such as iron and copper, it can always be revived with extraordinary intensity by touching them with potassa, soda, or one of the salts formed by lime, or by one of these bases.

Before concluding anything from the almost constant presence of the line D, it will without doubt be necessary to ascertain whether its appearance does not indicate the existence of the same substance mixed with all arc conductors. Nevertheless this phenomenon already appears to us a pressing invitation to the study of the spectra of the stars, for if, by good fortune, this same line should be discovered, stellar astronomy will certainly be able to make the discovery available.

I also endeavored to make these different arcs coincide, as in the case of that of carbon with the solar light, and under these circumstances I was again struck with the appearance of unexpected phenomena. During the coincidences of these various spectra, I saw the electric lines stand out upon the comparatively uniform ground of the solar spectrum, so that it might be seen that, notwithstanding their apparently accidental grouping, they all possessed the tint of color corresponding to their refrangibility. This determination can be made with certainty, since the standard of comparison is not far off.

But what is peculiarly striking in this experiment is, that among these electric lines there are some which possess an intensity absolutely enormously superior to that of the corresponding solar ray. Especially in the arc from silver there is a green ray, so to speak, inextensible by the prisms, and of a dazzling splendor. It is a true source of simple light, and as it is

insulated, and as the arc from silver is transparent, tranquil, and durable, there is nothing to prevent this ray from being made the source of a green light as intense as may be wanted; and from being utilized for the demonstration of phenomena heretofore indicated by theory alone. Photography will furnish the means of measuring the extreme intensity of this beautiful ray, of which, without doubt, the calorific action may also be established.

Other very intense rays have also their fixed places in different parts of these spectra, and even at their extremities, and there are great probabilities of discovering isolated lines, the rays corresponding to which cannot be seen in the solar light. L'Institut, 7th Feb. 1849.

Transportation of Solids by the Voltaic Arc.

M. Maas, Professor of Physics in the College de la Paix, at Namur, gave an account to the Academy of Sciences at Brussels, (4th November, 1848,) of an experiment which he thinks shews that, contrary to the usually received opinion, the transportation of the material of the electrodes is not always from the positive to the negative, but that the direction of motion depends upon the nature of the electrodes, and may be from the negative to the positive. This experiment was made at first with a Grove battery of 70 very small elements, the anode being a cylinder of very hard and fine-grained coke, while the kathode was a similar cylinder of a larger grain. "Whilst the pile was in operation, I remarked that the incandescent particles were thrown from the negative pole, not towards the positive, but in a direction which oscillated around a plane at right angles to the arc. The current being suspended, I found that the positive pole was only a little blunted, while the negative presented a kind of interior button, surrounded by a crown more raised than the rest, which the arc coming from the positive pole had avoided." The experiment was then repeated with another Grove battery of 15 larger couples, in order to satisfy the experimenter that the effect did not depend upon the peculiarity of the battery. He finally cites other experiments of Pouillet and Ermann, which he thinks lead to the same view.

But does his experiment prove anything, except that the current passes in preference by the more compact carbon, and that the irregular grain causes the material to fly, as is well known to be the case before the blowpipe?—*Ed. Journ. Fr. Inst.*

Statistics of Bookbinding in London.

Some idea may be formed of the extent of the London bookbinding trade from calculations which have been made, to the effect, that the weekly consumption of leaf gold, for enriching the exterior of books, amounts to about 3,600,000 square inches; and that 350 tons of paper shavings from book edges are sold annually by the London binders.

Lond. Builder, June, 1849.

Translated for the Journal of the Franklin Institute.

Analysis of Bran. Test for Albumen, &c.

M. Meller gives the following as the proximate analysis of a bran from a native wheat grown in the north of France in 1848.

Starch, dextrine, and sugar,	53·0
Liquorice sugar,	1·0
Gluten,	14·9
Fatty matters,	3·6
Lignin, (*woody fibre*,)	9·7
Salts,	0·5
Water,	13·9
Incrusting matters and aromatic principles, 3·4 (by difference.)	
	100.

EXTRACTS FROM PROCEEDINGS OF THE PARIS ACADEMY OF SCIENCES.

Translated for the Journal of the Franklin Institute.

A new process for transforming common Salt into Sulphate of Soda, by means of the Sulphate of Iron. Presented by MM. Emile Thomas, Dellisse and Boucard, *Civil Engineers. February* 5, 1849.

This process allows the very economical use of iron pyrites on one hand, and of the water of salt springs or of the ocean on the other.

The dry sulphate of soda is stated to cost only from one-fifth to one-seventh of its former price. Besides which, the new process avoids all the inconveniences arising from the discharge of the vapors of muriatic acid.

A process of this kind might be very useful over an extensive region of our country, where salt springs abound, while the rocks are filled with iron pyrites. From the sulphate, the carbonate and other salts of soda are made by well known processes.

Use of Anæsthetic agents during Surgical Operations.

Stanislas Julien has found, in examining the Chinese books in the National Library at Paris, the proof that the Chinese have been long acquainted with the use of anæsthetic agents during surgical operations. The extract which he gives is from a book published about the commencement of the sixteenth century, in fifty volumes quarto, and entitled, "*Kou-kin-i-tong. General account of ancient and modern Medicine;*" and refers to the practice of a celebrated physician—Ho-a-tho—who flourished between the years 220 and 230 of our era. It states that when about to perform certain painful operations, "he gave the patient a preparation of hemp," (Hachich,) and that at the end of a few moments "he became as insensible as if he had been drunk or deprived of life." After a certain number of days, the patient was cured without having experienced the slightest pain during the operation. In a subsequent notice he also shows

that the same physician used the hydropathic system as a cure for certain diseases, among others, chronic rheumatism.

Ground Nuts as a substitute for the Potato.

M. A. Richard, in a communication read at the meeting of the 12th February, 1849, recommended to the attention of cultivators the tubercles of our ground nut (*Apios tuberosa*,) as a substitute for the potato. He gives a minute account of the plant and its mode of culture, and states its advantages as follows.

First. Its chemical composition and sweet and agreeable taste have a strong analogy to those of the potato.

Secondly. They contain nearly twice as much nutritive matter as an equal weight of potatoes. (The numbers given by the analysis are 42·4 for the ground nut, and 25·6 for the potato.)

Thirdly. It resists the severest colds, and its culture will therefore be easy in France, which culture he thinks should be encouraged as an important resource in case the potatoes should fail entirely.

On the use of the fibres of the Banana tree in the manufacture of Paper.

A report made at the same meeting, by M. Payen, on behalf of a committee composed of himself and MM. Pouillet and Boussingault, speaks in high terms of the proposition of M. Roques to introduce the fibre of the banana tree into the manufacture of paper. This tree is grown extensively in the West Indies as a protection to the coffee plant, and as furnishing by its fruit sustenance for the slaves. In collecting the fruit the tree is cut down, and little or no use has hitherto been made of the stems. According to the report, the introduction of this fibre into paper has the advantage of giving, by a cheap material, which can be procured in great abundance, a greater strength to the paper, and of requiring less sizing, while the experiments made upon a large scale show that it presents no disadvantages in regard to the quality or color of the paper.

On the effect of Lightning.

In reference to a former communication on the subject of the effects of lightning, M. Miner states on the authority of M. Durant, a forest guard, well known for his integrity and observation, that he (M. Durant,) had remarked in his inspections that the trees struck by lightning were generally the largest and most leafy; but that sometimes the case was different. He states that upon one occasion, upon the edge of the forest of Ardennes, he had seen a poplar tree furnished with young branches along its whole trunk, struck by the lightning, which spared neighboring trees which were considerably higher, but had recently been trimmed. The same stroke killed an old man who was reading the Bible in his cottage, which was in the vicinity of the tree; and on the next morning a number of fishes in a neighboring pond, were found floating dead.

Upon the apparent diameter of the Sun.

At the meeting of the 19th February, M. Faye, in a very interesting communication upon the different estimates of the apparent diameter of the sun, recommends the Daguerreotype as a means of obtaining a very close approximation to the true value. The diameter of the image being measured micrometrically, and the focal distance of the object glass being

determined by the method which Bessell applied to the Fraunhofer heliometer. If an error of half a millimetre (0·02 in.) was made in the focal distance, and one of 0·005 mim. in the diameter of the image, the error of the determination, except from accidental and atmospheric causes, would be only 0·″14. He also recommends the same process for other similar determinations, and takes occasion to notice with admiration the application, upon our Coast Survey, of the electric telegraph to the determination of the differences of longitudes.

Notice of a Meteorological Phenomenon.

A second communication from M. Faye is in the following terms: "I observed to-night a phenomenon to which I call the attention of persons who interest themselves in meteorological optics. In coming out from a room which opens into the back of the observatory, I observed that the light of a gas lamp placed in the room some four or five yards behind me, produced in front of me, through the open door, a white rainbow like a lunar halo, the lower half of which was thrown upon the ground and the neighboring bushes. I measured roughly the angle subtended by the diameter of this circle, by means of two crossed rulers, and I found it to be between 80° and 90°—nearer 80°. As I was making arrangements to study this appearance more closely, by varying the light and the position of the lamp, the fog was nearly dissipated by a light west wind. This white bow ought to be easily re-produced during fogs, and where the nature of the vesicles of the fog will permit, it might be produced by means of the electric light, and thus studied more completely than I did."

Experiment upon the diameters of Newton's Rings.

MM. F. de la Provostaye and P. Desains, communicated some experiments upon the diameters of Newton's rings. Newton, in observing these rings under the different incidences of the light, was led to the supposition that the thicknesses of the thin sheets of air corresponding successively to a ring of the same order, varied as the secant of an angle u, such that

$$\sin. u = \frac{\left(105 + \frac{1}{n}\right)}{106} \sin. r.$$

Where n is the index of refraction of the glass, and r the angle which in the thin plate the ray of light makes with the normal.

As long as r is less than 60°, the numerical value of *secant* u does not differ sensibly from that of *secant* r, but when r exceeds this value, *sec.* u is less than *sec.* r, and above the value of $r = 80°$, the difference becomes considerable.

According to the undulatory theory, the thicknesses at all incidences ought to be proportional to *sec.* r. Fresnel and Herschel examined this difference, which according to the latter presents a serious objection to the undulatory theory. To explain it, they admitted the possibility of the law of Descartes being inaccurate in the very oblique passage of rays between two surfaces close to each other.

By their experiments, MM. Provostaye and Desains show that the deductions of Newton were erroneous, and that the theoretic law accords per-

fectly with experiment up to the highest limits at which the rings could be clearly seen. This limit is 85° 21′.

On the production of Anhydrous Nitric Acid.

At the same meeting a note was read from M. H. Deville, "on the production of anhydrous nitric acid." The following is the principal part of this interesting communication:

"In treating the nitrate of silver by absolutely dry chlorine, I have succeeded in isolating the anhydrous nitric acid, the existence of which has been demonstrated by numerous analyses. This beautiful substance appears in the form of colorless crystals of great brilliancy and limpidity, which may acquire considerable size. When they are slowly deposited in a current of strongly cooled gas, their edges may acquire a length of a centimetre, (four-tenths of an inch.) The atmosphere in which the anhydrous nitric acid exists in the state of vapor, and mixed with carbonic acid, may be perfectly colorless, but at the moment when the tube is closed by the blowpipe, there is developed a small proportion of hyponitric acid, which gives the gas a faint reddish tint. This has happened in the tube enclosing the specimen which I have the honor of submitting to the Academy."

"The anhydrous nitric acid crystalises in six sided prisms, which appear to be derived from a right prism with rhombic base. (larger crystals will in a short time allow me to determine exactly their form.) It melts at a temperature which does not much exceed 29° 5′ (85° Fahr.) and boils at about 45° (113° Fahr.) Its tension at 10° (50° Fahr.) is very considerable."

"The analysis of this body presents some difficulty owing to its tension, which produces, the moment the bulb is broken, a rapid disengagement of gas. Very soon the copper absorbs the vapors with such rapidity that there is a sudden absorption and deformation of the green glass tube in which the experiment was made. Nevertheless, by taking great precaution, I have succeeded in determining numbers which leave me no doubt."

"I have also succeeded in fixing the capacity of saturation, which corresponds to the formula $Az\ O_5$."

"Anhydrous nitric acid heats very much in contact with water, and dissolves without coloration, and without disengaging any gas; it then produces, with baryta, the nitrate of baryta, easily recognizable by its crystalline form."

"The decomposition of nitric acid, under the influence of heat, appears to begin nearly at its boiling temperature. This is an obstacle to the determination of the density of its vapor by the process of M. Dumas. I endeavored to reach this determination by a method which, however, presents the inconvenience of giving numbers depending upon a temperature too near the point of ebullition."

"The process by means of which I obtain the anhydrous nitric acid, is very simple; but the ease with which this body penetrates caoutchouc tubes, renders it necessary to connect all the pieces of the apparatus by welding. I employ an U tube, capable of containing 500 grammes (7500 grains,) of nitrate of silver, dried in the apparatus itself at a temperature of 180°, (356° Fahr.) in a current of dry carbonic acid gas. To

this tube is welded another U tube of a very large diameter, and provided at its lower part with a small spherical reservoir welded on to it. Into this reservoir will pass a liquid which is always developed during the operation, and is excessively volatile—(nitrous acid?) The nitrate of silver tube is plunged into water covered with a thin layer of oil, and heated by means of an alcohol lamp communicating with a reservoir in which the alcohol is kept at a constant level. The chlorine passes out from a glass gasometer, and its displacement is caused by a slow and constant flow of concentrated sulphuric acid. The chlorine must pass over chloride of calcium, and then over pumice moistened with sulphuric acid. At ordinary temperatures, no effect seems to be produced. The nitrate of silver must be first heated to 95°, (203° Fahr.) and then rapidly cooled down to 58° or 60°, (136° or 140° Fahr.) which temperature must not afterward be exceeded. During the first moments, hyponitric acid, recognisable by its color and its easy condensation, is developed; then when the temperature has reached the lowest point which I have assigned, the production of the crystals begins, and they will soon have obstructed the recipient, which is to be cooled to —21°, (—6° Fahr.) They are always deposited upon the part of the recipient which is not immersed in the freezing mixture, and I have found that ice alone is sufficient to determine their appearance. The gases are colored, and the little sphere of the cooled tube contains a small quantity of liquid, which must be removed from the apparatus before the nitric acid is transferred. This latter operation is easily performed by replacing the current of chlorine by one of carbonic acid. The cooling of the condenser is then stopped, and the bulb intended to receive the crystals, which is fastened to the apparatus for their production, by means of a caoutchouc tube lined with asbestos, is plunged into the freezing mixture."

"The chlorine must pass very slowly, not more than from three to four litres (*quarts*) in twenty-four hours. Nevertheless, all the gas is not absorbed by the nitrate of silver; oxygen is developed. An apparatus thus arranged will work night and day without superintendence. Only from time to time the sulphuric acid which displaces the chlorine, the alcohol which furnishes the lamp, and the materials of the freezing mixture, must be renewed."

"I will have the honor soon of submitting to the Academy a more complete memoir, in which will be found described the chemical properties of anhydrous nitric acid, and in which I will record the result of the examination which I am pursuing of the action of chlorine and of hypochlorous acid upon the salts of silver."

On the manufacture of Gun Cotton.

M. A. Gaudin communicated some remarks upon gun cotton, in which he endeavored to account for the very different results which experimenters had obtained from it. He thinks that there are an infinite number of intermediate products of the method of manufacture, from the product which merely burns, to that which fulminates. The product which burns slowly is obtained by immersing the cotton in concentrated sulphuric acid mixed with saltpetre, while the fulminating compound results from cotton immersed in a mixture of monohydrated nitric acid mixed with Nordhausen

sulphuric acid, and the formation of this latter product appears moreover to be instantaneous.

If it appears that this latter supposition is true, then all specimens prepared upon any thing like a large scale, must be composed of a series of various products of different degrees of energy. The part first moistened may be the most energetic, and that which was first wet being able to burn only.

He also believes that the spontaneous explosions which have occurred from it, are due always to insufficient washing.

(His suggestions as to the instantaneous formation of the fulminating cotton, and the cause of its spontaneous explosions, may be correct, but he is decidedly in error as to the nature of the compound made by immersing the cotton in sulphuric acid and nitre. With the proper precautions a very excellent gun cotton may be prepared in this way.)

AMERICAN PATENTS.

Bain and Morse's Telegraphs.

Decision of Judge CRANCH in the case of ALEXANDER BAIN, Appellant, *vs.* SAMUEL T. B. MORSE, Appellee.

From the Daily Union, April 5, 1849.

Upon the question of interfering applications for a patent:

The Commissioner, upon hearing, decided that Mr. Bain's claim interfered with Mr. Morse's, and that Mr. Morse was the first inventor; and rejected the claim of Mr. Bain. From this decision Mr. Bain has appealed.

It is contended by the counsel for Mr. Morse, that the judge upon appeal has no jurisdiction of the question of interference,—that an appeal is given only upon the question of *priority of invention;* and that upon the question of interference the decision of the Commissioner is conclusive.

Whether it be thus conclusive, then, is the first question to be decided.

By the act of 1836, ch. 357, sec. 7, it is enacted, that "if the specification and claim shall not have been so modified as, *in the opinion of the Commissioner*, shall entitle the applicant to a patent, he may, on an appeal, and upon request in writing, have the decision of a board of examiners, to be composed of three, &c.: and on examination and consideration of the matter by such board, it shall be in their power, or of a majority of them, to reverse the decision of the Commissioner, either in whole or in part; and their opinion being certified to the Commissioner, he shall be governed thereby in the further proceedings to be had on such application."

This section is applicable to cases where there is no conflicting applicant, and shows that the legislature, by saying, "*if in the opinion of the Commissioner*," &c., did not intend to make that opinion conclusive. On the contrary, it provides "that the board shall be furnished with a certificate, in writing, of the opinion and decision of the Commissioner, stating the particular grounds of his objection, and the part or parts of the invention which he considers as not entitled to be patented; and that the said board shall give reasonable notice to the applicant, as well as to the Commissioner, of the time and place of their meeting," &c. All these provi-

sions were evidently intended to enable the board of examiners to revise the opinion and decision of the Commissioner, and show that his opinion was not to be conclusive.

By the 8th section of the same act, (1836,) it is enacted, "That wherever an application shall be made for a patent which, *in the opinion of the Commissioner*, would interfere with any other patent for which an applieation may be pending, or with any unexpired patent which shall have been granted, it shall be the duty of the Commissioner to give notice *thereof* to such applicants, or patentees, as the case may be; and if either shall be dissatisfied with the decision of the Commissioner on the question of *priority* of right or invention on a hearing thereof, he may appeal from such decision, on the like terms and conditions as are provided in the preceding section of this act; and the like proceeding shall be had, to determine which, or whether either, of the applicants is entitled to receive a patent as prayed for."

The question of priority of right or invention necessarily implies *interference.* The Commissioner, before he could decide the question of priority, must have decided that of interference; for without interference there can be no question of priority. Before I can have jurisdiction of the question of priority, I must be satisfied that there is an interference; and I must decide the question of jurisdiction as well as any other question which arises in the cause.

The opinion of the Commissioner, (mentioned in the 8th section,) that interference exists, only justifies him in *giving notice thereof* to the other applicant, and appointing a day to hear the parties upon that question.—He decides it only *pro hoc vice*, and for that purpose only. Upon that hearing he is to decide; and from that decision, if either shall be dissatisfied with it, on the question of priority, iucluding that of interference, he may appeal; and upon such appeal, as I understand the law, the judge, in case of real interference, may "determine which, or whether either, of the applicants is entitled to receive a patent as prayed for." The scope thus given to the judge is broad enough to include the question of interference as well as that of priority, if it should arise.

By the act of 1836, ch. 88, sec. 11, it is enacted, "That in all cases where an appeal is now allowed by law from the decision of the Commissioner of Patents, to a board of examiners provided for in the 7th section of the act to which this is additional, the party, instead thereof, shall have a right to appeal to the Chief Justice of the District Court of the United States for the District of Columbia, by giving notice thereof to the Commissioner, and filing in the Patent Office, within such time as the Commissioner shall appoint, his reasons of appeal specifically set forth in writing; and also paying into the Patent Office, to the credit of the Patent Fund, the sum of twenty-five dollars.

"And it shall be the duty of the said Chief Justice, on petition, to hear and determine all such appeals, and to revise such decisions, in a summary way, on the evidence adduced before such a Commissioner, at such early and convenient time as he may appoint, first notifying the Commissioner of the time and place of hearing, whose duty it shall be to give notice thereof to all parties who appear to be interested therein, in such manner as the said judge shall prescribe.

"The commissioner shall also lay before the said judge all the original papers and evidence in the case, together *with the grounds of his decision*, fully set forth in writing, *touching all the points involved by the reasons of appeal*, to which the revision shall be confined."

One of the reasons of appeal in this case is, that there is no real or substantial interference between the two applications.

The question of interference, therefore, is involved by the reasons of appeal, and must be decided by the judge. By limiting the jurisdiction of the judge to the points involved by the reasons of appeal, the legislature has affirmed it to that extent.

The interference mentioned in the 8th section of the act of 1836, must be an interference in respect to patentable matters; and the claims of the applicants must be limited to the matters specifically set forth as their respective inventions; and what is not thus claimed, may, for the purpose of this preliminary inquiry, be considered as disclaimed.

The question then is, does Mr. Bain claim a patent for any matter now patentable for which Mr. Morse claims a patent?

To answer this question, it is necessary to ascertain for what patentable matter Mr. Morse now claims a patent.

In his specification, filed January 20, 1848, he says: "What I claim, as my own invention and improvement, is the use of a single circuit of conductors *for* the marking of my telegraphic signs already patented, for numerals, letters, words, and sentences, by means of the decomposing, coloring, or bleaching effects of electricity, acting upon any known salts that leave a mark as the result of the said decomposition, upon paper, cloth, metal, or other convenient and known markable material. I also claim the invention of the machinery as herein described, for the purpose of applying the decomposing, coloring, or bleaching effects of electricity acting upon known salts as herein before described."

The Commissioner, in his written decision in this case, says: "Such use of a single circuit [i. e. to produce marks upon chemically prepared paper] is not the point at issue; *nor is this claimed by either party.* Said Morse claims using a single circuit of conductors for a certain purpose, or in a certain way, viz: to mark his telegraphic signs; and also claims the machinery by which he accomplishes this purpose. Said Bain does not specifically mention in his claim using a single circuit, though this must be considered an essential part of his invention and claim, and is necessarily involved in the final clause of his claim, to wit: 'So that in either case these form the *received communication*, substantially in the manner and with the effects described and shown.'"

The Commissioner proceeds: The third clause of the claim of said Bain, with which the true claims of said Morse interfere, is as follows, to wit:

"Third, The application of any suitable chemically prepared paper, without regard to the chemical ingredients used for such a purpose, to receive and record signs forming such communications—such signs being made by the pulsations of an electric current or currents, transmitted from a distant station, said currents operating directly, and without the intervention of any secondary current or mechanical contrivance, through a suitable metal marking style that is in continuous contact with the receiving paper,

thereby making marks thereon; which marks correspond with the groups of perforations in the paper *composing* the transmitted communication; or may be given by the pulsations from the spring 45 and block 46; so that in either case these form the received communication substantially in the manner and with the effects described and shown, including any merely practical variations, analogous and equivalent in the means employed, and the effects produced thereby."

The Commissioner, in his written decision, says:

"The invention, it will be seen by reference to the specifications of the parties respectively, does not consist in the use of the electric current to make marks upon chemically prepared paper; nor making marks through a single line of conductors; nor could a claim to either of these devices have been entertained as patentable, as they have been long known."

Again: It is said by the counsel of Mr. Morse, "it is admitted that neither could patent the *battery*, the *circuit*, the prepared paper, or the marking by the electro-chemical process—it was only a *new combination* of the several parts so as to produce a new result, *or an old result in a better manner*, that either could patent."

Again: The Commissioner, in his "*reasons of decision*," says: "It is true, as Mr. Bain asserts, that no one can monopolize the use of air, fire, or water; but it is equally true that any one can monopolize the use of air, fire, or water, upon certain principles of operation which he may have invented or discovered; and this is precisely what the respective claimants, in this case, demanded as their rights, and gave rise to the interference, viz: each claimed the right to use, and exclude others from using, galvanic power to mark certain signs [which signs have been already patented by said Morse] upon chemically prepared paper through a single circuit of conductors.

"*A single circuit of conductors*, consisting either wholly of wire, or in part of wire and part of earth, for telegraphic purposes, *were not new;* the *signs or signals* to be marked *were not new*, the same having been before patented by said Morse, and *chemically prepared paper*, for receiving telegraphic signs by galvanism, *was not new*, the same having been patented in England in 1838, by Mr. E. Davy. Moreovor, the *use of a single telegraphic circuit*, for marking the aforesaid signs upon paper, *was not new*, the same having been before patented by said Morse.

"Neither party claimed any one or any two of the above elemental features. *The invention of each was made up of the three combined;* and the advantages claimed to have been discovered by each, in these combined operations were identical."

If, then, these matters are not now patentable in themselves, there is nothing patentable in Mr. Morse's claim left to be interferred with, except his claim of a patent for his invention of the machinery described in his specification, or for his combination of machinery and materials, as described therein. The claim of each applicant, therefore, is reduced to the claim *for the combination of machinery and materials* which he has invented, and does not include any of the matters claimed in his specification which are not now patentable.

These combinations seem to me to be far from identical. Mr. Bain includes in his combination the use of the perforated paper, for *composing* the

communication; and of the style which passes the electric current through the perforated paper; and the machinery for transmitting the same communication to several different places at the same time. It is said that the style is not new; but he makes it an ingredient in his combination, and in that respect his combination differs from that of Mr. Morse, and it is a very important item in connexion with the perforated paper. He includes in his combination new patentable matter with old matter, not patentable, and thereby makes a new patentable combination. This new matter, thus introduced into the new combination, is admitted to be patentable in itself without combination with the old unpatentable matter; and, indeed, it seems to be a great improvement in the transmission of telegraphic information.

But it is said that Mr. Bain is only authorized to obtain a separate patent for each of those inventions, and cannot claim a patent for his new combination of the old and new together. If, however, his new combination of old materials be patentable, (which must be admitted, or it would not interfere with Mr. Morse's claim,) it seems to be not the less patentable because it includes the new matter in connexion with the old. The old matter may not, in itself, be patentable, but joined to the new matter, a combination may be formed which may be patented. He is not obliged to take separate patents for each new patentable matter. He does not now ask for them; he may be willing to ask only for a limited use of those new matters—*to wit: in combination;* and not for an exclusive use of them for every purpose to which they may be applicable.

Mr. Godson (in p. 63) says: "A combination or arrangement of old materials, when, in consequence thereof, a new effect is produced, may be the subject of a patent. This effect may consist either in the production of a new article, or in making an old one in a better manner, or at a cheaper rate." "This manufacture may be made of different substances mingled together, or of different machines formed into one, or of the arrangement of many old combinations." "Each distinct part of the manufacture may have been in common use, and every principle upon which it is founded may have been long known, and yet the manufacture may be the proper subject for a patent. It is not for those parts and principles, but for the new and useful compound, or thing thus produced by combination, that the grant is made; it is for combining and using things before known, with something then invented, so as to produce an effect which was never before attained."

The counsel of Mr. Morse, in argument, said:

"It is obvious, and is admitted by our adversaries, that Morse's instrument is a very different thing, in its *form* and *structure*, from Bain's."—But *form* and *structure* are very important matters in machinery; and if they enable the operator to do the work in a better manner, or with more ease, or less expense, or in less time, it is no interferenee; but is an improvement for which the inventor may have a patent.

When the application is for a patent for a combination of machinery and materials, form and structure become *substance;* they are of the essence of the invention; and an admission that Morse's instrument is a very different thing, in its form and structure, from Bain's, is an admission of a fact which is *prima facie* evidence, at least, that there is no interference between the two, and throws the burden of proof on the other side.

There was no evidence laid before the Commissioner of Patents upon the question of interference, so that he must have adjudged the interference upon a comparison of the two specifications; possibly without considering that the only patent which either could obtain would be a patent for his own combination—all the materials of which Mr. Morse's combination consists being old, and not now patentable.

The question is not now whether the claims of Mr. Bain and Mr. Morse interfere as to matters not now patentable, but whether they interfere as to matters *now patentable;* and the only matter now patentable in Mr. Morse's specification is his own combination of machinery and materials. That combination constitutes his machine; and his machine is admitted to be a very different thing, in its form and structure, from Mr. Bain's. Form and structure constitute the identity of machinery. The combination consists in *form* and *structure;* and the patent, if issued, will, I presume, be issued for the *form* and *structure* of the instrument.

It being admitted that the form and structure of Mr. Bain's instrument is very different from Morse's, there can be no interference in that respect, and if form and structure constitute the identity of machinery there is no interference in the two instruments; and if the instruments are the combinations, or the result of the combinations, for which patents are now claimed, there is no interference in the two instruments in regard to any matter now patentable.

But it is not necessary to rely alone upon the admission of Mr. Morse's counsel, to show that there is a great difference between the machinery used by the contending applicants to effect the object: i. e. the rapid transmission of intelligence by the power of the electric current. Any one who will compare the two specifications, and drawings and models, will at once perceive the difference.

A patentable improvement is not an interference.

The Commissioner, in his written decision, says: "It appears from the records of the office, that the application by said Alexander Bain, subject of Great Britain, was made April 18, 1848; and upon examination of his claims, it was found that the before-mentioned claim could be *admitted to patent*, no invention of a like character appearing in the public records of the office, nor in any printed publication. Prior, however, to the final issue of the case, the secret archives were consulted; and it was found that an application, filed by Samuel F. B. Morse, January 20, 1848, had been there deposited, in compliance with provisions of law, which presented claims conflicting with those, before mentioned, set up by said Bain."

This shows that but for the supposed interfering claim of Mr. Morse, Mr. Bain was entitled to his patent; and if there be no interference in respect to patentable matter, he is still entitled to a patent for his own combination.

But the counsel for Mr. Morse say: "There is an interference—that Bain's third claim palpably covers the whole of Morse's first claim; and, if granted, Bain could do all that Morse claims an exclusive right to do; he could write Morse's characters precisely as Morse does; and that herein consists the interference."

But the only matter now patentable, and claimed in Mr. Morse's speci-

fication, is *his peculiar combination of material and machinery, as therein described.* All the materials used in that combination are old; and he will not, under this patent, be entitled to the exclusive use of any of them separately, or in any other combination than that which he has described in his specification. There cannot be a patent for a *principle;* nor for the application of a principle; nor for an effect. Two persons may use the same principle and produce the same effect *by different means,* without interference or infringement, and each would be entitled to a patent for his own invention.—*Godson,* 63, 68, 74.

So, in the present case, although the power used by both applicants is the same, and the subject the same, yet, as the effect is produced by means which appear to me so different as to prevent an interference, *the question of priority of invention does not arise.* It is, therefore, not a case under the 8th section of the act of 1836, but under the 7th section of the same act. So that each of the applicants may have a patent for the combination which he has invented, and claimed and described in his specification—provided he shall have complied with all the requisites of the law to entitle him to a patent.

If this were a doubtful question, I should think it my duty to render the same judgment, so as to give Mr. Bain the same right to have the validity of his patent tested by the ordinary tribunals of the country, which Mr. Morse would enjoy as to his patent; and finally, to obtain the judgment of the Supreme Court of the United States upon it. For if the Commissioner and the Judge should reject Mr. Bain's application for a patent, the decision would be final and conclusive against him, unless he could obtain relief by a bill in equity under the 16th section of the act of 1836, and the 10th section of the act of 1839; which, it is said, is doubtful.

I am, therefore, of opinion, and so decide—

That there is no interference in the claims of these applicants, in relation to any matter (contained in their respective specifications) *now patentable;* and therefore that Samuel F. B. Morse is entitled to a patent for the combination which he has invented, claimed, and described in his specification, drawings, and model. And that Alexander Bain is entitled to a patent for the combination which he has invented, claimed, and described in his specification, drawings, and model; provided they shall, respectively, have complied with all the requisites of the law, to entitle them to their respective patents.

I deem it unnecessary, therefore, to decide upon any other points involved by the reasons of appeal.

W. CRANCH.

Washington, D. C., March 12, 1849.

FRANKLIN INSTITUTE.

Proceedings of the Stated Monthly Meeting, June 21st, 1849.

Samuel V. Merrick, President, in the chair.
Isaac B. Garrigues, Recording Secretary.
The minutes of the last meeting were read and approved.

Donations to the Library and Cabinet were received from—J. W. P. Lewis, Esq., Philadelphia; William J. McAlpine, Esq., Brooklyn, N. Y.; and Messrs. J. N. Churchill & Co., Hamden, Connecticut.

The Treasurer read his monthly statement of receipts and payments.

The Board of Managers and Standing Committees reported their minutes.

New candidates for membership in the Institute were proposed, and those proposed at the last meeting were elected.

In the absence of the Chairman of the Committee on Meetings, Prof. Frazer exhibited a model of Parker's Water Meter, and explained its construction by means of diagrams.

This instrument is not dissimilar in its construction to the rotating steam engine invented by Bramah & Dickinson, in 1790. (*Galloway & Hebert's History of the Steam Engine, p.* 106.) It consists of a hollow iron drum or cylinder, closed at each end, and firmly attached by its end plates to an axis, which rotates with it. This drum is enclosed in an outer concentric case, through which the axis passes water-tight, leaving sufficient room between them for the passage of the water, which, entering this space, passes around the drum, and escapes by another pipe immediately above its place of entrance. Between the orifices of the two pipes a fixed diaphragm passes across the space between the drum and casing, so as to prevent the water from passing the machine without making its circuit. Through slots in the cylindrical surface of the drum two sliding vanes move freely, of sufficient length and breadth to close the space between the drum and casing. These vanes are at right angles to each other, and are notched, so as to permit them to move freely to a certain extent past each other, in the inner drum. The axis of the drum carries upon it a pinion, by which it is connected with a train of wheels which register its revolutions, as in the ordinary counters. The operation of the machine is as follows: The water entering upon one side of the casing, just below its horizontal diameter, passes along the lower part of the water space, and comes in contact with one of the sliders, which has, by its own gravity, (or by the action of a spring arranged in the upper part of the machine,) fallen across this space; by its pressure it forces this vane around, thus causing the inner drum and its axis to rotate until it reaches the exit pipe, where it escapes. At each fourth of a revolution one of the vanes thus obstructs the passage, and the axis is thus kept, during the passage of the water, in constant rotation, and by its wheels registers the quantity of water passing, when the contents of the water space is once carefully determined. The machine is made to move with a very slight force, and experiments have shewn that the error of its register, varying with the velocity of the machine, (being greatest at low velocities,) does not exceed from 2 to 5 per cent. of the amount of water, and is always in favor of the consumer. A careful set of experiments on each machine, at various velocities, will furnish the means of correcting this error. The machine is made by Messrs. Berkenbine, Martin & Trotter, of this city.

Mr. Whitall exhibited and explained a series of maps of the Heavens, got up by him on a large scale for the purpose of teaching astronomy.

Mr. Root submitted for the inspection of members a number of exceedingly beautiful daguerreotype portraits made by him, and explained the method by which he is enabled to produce a gradual fading away of the

drapery from above downwards, by which a much increased effect is given to the head. Pictures of this kind are called by him Crayon Daguerreotypes.

Prof. Frazer exhibited a new and very simple and compact filter, invented by Mr. Latting, of New York. It consists of two concentric tubes, the inner one of which is closed above and is pierced with holes over a portion of its length; around this a piece of flannel or other suitable material is wrapped, and the tube is then placed within the other, in which it fits loosely, and is supported in a concentric position by a collar below. The upper end of the outer tube being screwed on to the hydrant, the water passes through the flannel, and being thus filtered into the inner tube escapes below. When the filtering cloth has become foul, it can easily be withdrawn and another substituted. Prof. F. took occasion to remark that a very similar contrivance had been used and recommended to him several years ago, by Mr. Robert Cornelius, of this city. In that filter the current of water could be passed in either direction, and the filter be thus cleansed.

Prof. Frazer also called the attention of the meeting to a new tilting wagon, invented by Mr. Start, of Dover, Delaware, a model of which had been deposited in the Institute by the inventor. In this contrivance the wagon body was made to slide backwards by friction rollers, over two plates of iron placed on the framing, and of such length as to allow the centre of gravity of the loaded body, when rolled back, to project over the end of the frame. The load would then tilt by its own weight simply. In order to prevent this backward sliding of the wagon body when not desired, two semi-cylindrical cavities, placed at the front end of the rail plates, receive the friction rollers when the body is at rest, and prevent it from moving backwards by every sudden jar, or by the motion of traveling. A series of levers, the outer one of which projects a little beyond the side of the wagon, serve to start the body from this position, and permit it to move backward at the proper time.

Prof. Frazer also laid before the meeting a model of a proposed improvement in rails for railroads, invented by Mr. Elgar, of Baltimore. The object of this improvement is to give uniformity of strength over the whole rail, and to prevent horizontal or vertical displacement. The mode of securing these advantages consists of forming the rail in two similar parts, which are bolted together at distances of two or three feet, and break joints with each other. As the pattern of each part is very simple, the rails can easily be rolled of a length of 20 feet, and a joint will then occur half-way across the rail only, at each 10 feet. To strengthen the rail at each joint, a core of iron is introduced into the hollow of the rail at these points, so as to compensate for the weakness produced by cutting the rail at that point. Mr. E. also presents in the model a new method of fastening the chairs, by means of which the tendency of the shocks to loosen the rail is entirely avoided.

Prof. Frazer then read to the meeting an anecdote of the first trip of Mr. Robert Fulton with his steamboat on the Hudson river, in 1807, submitted to the French Society for the encouragement of National Industry, by M. Michaux, the distinguished botanist, and translated for publication in the Journal of the Institute.

COMMITTEE ON SCIENCE AND THE ARTS.

Report on the Catoptric, Dioptric, and Catadioptric Systems of Lights for Lighthouses.

The Committee on Science and the Arts, constituted by the Franklin Institute of the State of Pennsylvania, for the Promotion of the Mechanic Arts, in compliance with the following resolution, passed by the Franklin Institute at their meeting held April 19th, 1849, viz: "*Resolved*, That the Committee on Science and the Arts be requested to examine and report to the next meeting of the Institute, their opinion of the relative value of the present Catoptric System adopted in the United States, compared with the Fresnel Dioptric and Catadioptric System established in the Lighthouses in Europe and elsewhere, so far as the same can be obtained from documents in the possession of the Institute," REPORT:—

That they have examined the subject intrusted to them with the care and attention which its great importance demands. The immense amount of property, and the many valuable lives dependent on the proper illumination of coasts and harbors, have attracted the attention of men of science, and of nearly all civilized governments. The results have been witnessed in the very great improvements in the structure of lighthouses, and in their reflecting and refracting apparatus, especially of the latter.

The Committee have studied the voluminous documents containing not merely the opinions of a number of the most scientific men in Europe and America, but the actual practical results described in official statements of Lighthouse Boards, in every country where lights of high character have been established. They also have examined much voluminous correspondence, and have endeavored to avail themselves of every attainable source of information relating to the subject. They have also examined the Dioptric and Catadioptric Apparatus of Fresnel, as displayed in the four orders exhibited before the Franklin Institute.

The Catoptric System adopted in the United States is a very imperfect imitation of the European method, which was in use long before its *alleged* invention in this Union. Paraboloidal reflectors, with lamps placed in their foci, were in use nearly seventy years since, in France and Great Britain. The addition of a convex lens in front of the lamp, placed in the focal point of such a reflector, could only have been suggested by a person entirely ignorant of the elementary principles of optics.*

We need not, however, at present enter into the history of the lighthouse system in the United States. We are gratified to learn that a few improvements have been made by the introduction of better forms of reflectors, and in their adjuncts, as well as in their size, finish, and mountings, but these few cases are merely exceptions to the general rule; and it must be acknowledged that the Catoptric System of this country is, in actual practice, far inferior to the Catoptric System of Europe.[1]† We do not deem the former to be of sufficient value to contrast with the Dioptric and Catadioptric Systems of Fresnel, which is rapidly superseding even the latter (the reflecting system) in its best condition. We therefore limit our comparison to the reflecting apparatus of Europe and the apparatus of Fresnel.

A paraboloidal reflector of the best description receives but two-thirds

* The small spherical reflectors are also defective in principle, but it is not necessary to discuss the defects of this antique apparatus.

† These numbers refer to articles in the Appendix, which will be found in the next number.

of the light emitted from the lamp; half of this only is reflected, equal to one-third of the whole,[2] and of this third a portion is intercepted by the intervention of a part of the lamp, diminishing the available light to less than one-third—perhaps to one-fourth; and of this one-fourth, a considerable portion is, from the divergence of the penumbral cone, too faint to produce much effect at great distances. In fixed lights many such reflectors are arranged in one or more circles or arcs; but even when very numerous, viz. from twenty to thirty, the light is very unequally distributed, and in some azimuths is invisible; when the reflectors are less numerous, viz. from ten to twenty, this defect is still more manifest.[3]

With the refracting and Catadioptric apparatus of Fresnel for fixed lights, the whole circle is equally illuminated, (especially when the latest improvements have been introduced,)[4] and nine-tenths nearly of the light emitted from the lamp is rendered available*[5]—glass, as a refracting material in this system, possessing the same advantage over reflectors as the refracting telescope possesses over the reflecting species. The consumption of oil to produce an equal light might readily be inferred to be much less, and practice has proved beyond a doubt that such is the fact.[6]

The superiority of the revolving and of the flashing lights of Fresnel over the revolving reflecting lights must also be conceded.[7] The superior brilliancy of these lights, the intense concentration of their rays, consequently their penetrating power, as well as their *economy in the consumption of oil*, being manifest to the Committee, it remains to inquire whether their first cost or the expense of their management be greater.

In Europe, *for a light of equal intensity*, the first cost is not greater, but as in practice the Fresnel lights are *much more intense* than the reflecting lights, *the first cost* of the apparatus is, in a small ratio, greater than that of the latter, *when of the best description*,[8] (of course we do not allude to the imperfect apparatus in this country,) but their great economy in oil is more than a compensation for the small additional prime cost.[9] They do not require more persons to attend to them, although, in fact, more are required in Europe, for both reflecting and refracting lights, than in the reflecting lights in the United States, but this increase is entirely owing to the importance there justly attached to the maintenance of a steady constant light, which cannot be insured in either system when one keeper only is employed.[10]

The Committee are strongly impressed with the great excellence of the Fresnel system,—a system which has already been established in nearly three hundred places (and everywhere with satisfaction) in Europe, where it is gradually superseding the old and imperfect Catoptric lights, whilst in no instance has it been abandoned after it has been established.

The opinion of scientific men throughout the world is believed to be decidedly in favor of the Fresnel system of lights, where a large arc of a circle requires illumination. In the United States, this invention has been introduced only at one station. The Committee earnestly hope that our whole coast, wherever it may be adapted to them, on both oceans, and on the lakes, may speedily be provided with this brilliant, economical, and admirably devised gift of the science and art of the nineteenth century

By order of the Committee, WILLIAM HAMILTON, *Actuary.*

Philadelphia, May 10th, 1849.

* Subject, of course, to a *small* deduction in the passage through the glass.

Mechanics' Institutes and Exhibitions of American Manufactures.

The rapid increase throughout the Union of Mechanics' Institutions, and the establishment of regular periodical exhibitions of American Manufactures in our principal cities, furnish to the lover of his country a very gratifying evidence of the healthy condition of public sentiment on these important subjects among our citizens. Especially cheering is the extension of these institution in the Western and Southern portions of our country. The experience of our own Institute proves the vast advantages which accrue from them to the mechanic, both in furnishing him with facilities of improvement in his branch of industry, and in elevating his character as a thinking and independent member of the community. And nothing can more tend to promote the feeling of mutual attachment among the citizens of our widely spread republic, which is so essential to the preservation of our Union, and we believe so much desired by the mass of the community in all sections of the country, than the healthy rivalry and friendly communion which such institutions excite and promote.

We have received the circulars announcing exhibitions during the ensuing autumn in the cities of Cincinnati and Baltimore. Our own annual will also be held as usual, as well as that of the New York American Institute. There will probably be others of which we have not yet heard. The order of the above is as follows:—The Tenth Annual Exhibition of American Manufactures will be held under the direction of the Mechanics' Institute, in the city of Cincinnati, commencing on the 5th of September, 1849; the rooms will be opened for the reception of goods on the 1st of August. The Second Exhibition of the Maryland Institute for the Promotion of the Mechanic Arts will be opened at the Washington Hall, in the city of Baltimore, on Thursday, the 27th of September, 1849, and will close on Saturday, the 13th October; goods will be received from the 20th September. The Exhibition of the New York American Institute will be opened at Castle Garden, on Tuesday, 2d of October; goods will be received on the 28th and 29th of September. The Franklin Institute will open its Exhibition in the halls of the Museum Building, in the city of Philadelphia, on Tuesday, October 16th, and it will be closed on Saturday, 27th of the same month. The rooms will be ready for the reception of goods on Friday the 12th of October.

Our opening remarks were elicited by the perusal of a pamphlet which has been sent to us, (and for which we return our thanks,) containing the "*Constitution of the South Carolina Institute for the Promotion of Art, Mechanical Ingenuity, and Industry; adopted January*, 1849; together with an Address to Mechanics, Manufacturers, and others interested in its objects. It was gratifying to see this additional evidence of what the recent establishment of manufacturing establishments in the South had taught us, that our Southern brethren were awaking to their true interests and duties, and it was doubly pleasing to find, upon perusing this address, that while they appreciate and frankly acknowledge their present position, they are now disposed to exercise their well known energy to recover the importance and influence which will be justly their due. The address is very ably conceived, and we are sure must produce the effect for which it was

intended. It is plain and statistical in its statements, frank in its declarations, and moderate in its tone, and the only error that we can point out in it, is the use of the word "*foreigners*," as applied to citizens of other States. We have no doubt that this is an inadvertence, but one of which mischief makers (who are truly foreigners in such institutions) will gladly take hold, and we can assure our Southern friends that we neither are, nor intend to be, foreign to them in any respect.

If our limits would permit, we would gladly reproduce the whole of this able address; as it is, we present some extracts from it as a specimen of its tone.

The following statement is an interesting addition to our statistics:—

"In South Carolina, where coarse goods are only made, its value is increased three times. The quantity of cotton cloth, of every kind, used in South Carolina the last year, was not far from thirteen million yards, worth about one million dollars. The cost of the raw material used was about $300,000—the remaining $700,000 was paid by the people of this State to those who spun and wove the cloth, transported the cotton and goods, and furnished the capital for manufacturing. A small portion of these goods have been made by our own factories, and so far the money has been circulated among our own people, but the greater part has passed to foreign hands."

"We ought to be prepared here, in Charleston, to furnish the machinery wanted to manufacture this cloth for South Carolina, and there never was a more inviting prospect opened for enterprise and capital, nor a more favorable location presented than is now offered in our city for the establishment of a machine shop for constructing cotton and woollen machinery."

"It has been objected by some, that cotton factories would become so numerous, the business would be overdone, and ruin would follow. It certainly need not be *our* fear just yet, that *we* shall glut the market with goods, when all the spindles in the whole south are outnumbered three times over by *Lowell alone*. When we have superseded northern fabrics in the various markets of our country,—when the product of our factories shall reach one hundred and fifty million of dollars per annum, as do the northern looms,—then we may begin to look abroad for relief from the burthen of over production; but even then we may *hope* that, as we have so much advantage, we may successfully compete with old or New England, in China, South America, and other foreign markets. In the mean time, let us quietly supersede northern goods in *our own*."

The following anticipations we will gladly see realized:—

"Those who are familiar with the characteristics of the people of the Southern States, can say whether she will be likely to slumber again over her destiny, or whether she will not go forth with that vehemence of energy which has been more than once exhibited under other circumstances. It may be hard to change old habits and fixed policies among us,—it has been hard and laborious work,—but be assured the course of public opinion is beginning to carry us *onward*, and soon it will rush with overwhelming power through every section of the South, bearing nobly on those who yield to its influence, but overwhelming those who would check its career."

On page 19 we have an interesting anecdote, important in its bearing, which we do not remember to have before seen.

"The history of the Hon. Samuel Williston, is a singular evidence of the great results obtained by industry in a mechanic pursuit. He commenced the making of the same little article, "buttons," in 1826, in his father's kitchen. Within ten years afterwards, he had regenerated his native place; had given an impulse to business; had built academies and churches; had created a flourishing town upon the ruins of a thriftless village, and had in his employment, at one time, two thousand persons; he has now amassed a fortune, besides giving, during the last ten years, more than $100,000 to colleges and schools!"

The following will interest some of our readers who are looking for an opening to establish themselves as machinists:—

"South of the Potomac, you can find no machine shop where cotton and woollen machinery is made, and yet the South is calling, in loudest tones, for the establishment of cotton

and woollen factories over her whole extent. In Georgia, there are now forty-two cotton factories, and in South Carolina, thirteen. These have cost, for machinery, not less than two million of dollars, while the freight alone, from northern workshops to southern seaports, has been not less than $100,000, and the demand for this kind of work is constantly increasing.

"We would invite earnest consideration on the part of capitalists and practical machinists to this point. Charleston is peculiarly located to favor the establishment of a machine shop on a large scale. Experienced workmen can be obtained, and work can be done here as cheaply as in Paterson, Providence, or Taunton, *after patterns* have once been procured.—Look at the machinery which passed into and through Charleston and Savannah the last year:—

Augusta Manufacturing Company	$100,000
Graniteville " "	120,000
Charleston " "	50,000
One or two small factories in Georgia	30,000
And orders yet unfilled, to an equal amount,	$300,000

"This machinery is burdened with charges for freight, transportation, &c., equal to 10 per cent., $30,000. This is a subject of deep interest to those in Charleston, who are engaged in manufactures, or intend to be. Machines made here would save both freight and boxing! and these two items would be a splendid *bonus* for a new establishment. Be assured *northern enterprise* and *capital* will not long overlook the opening for business here presented."

The conclusion of the address expresses the intentions and aim of the Association in strong and eloquent language, and contains statements which cannot too often be brought before, or too strongly pressed upon, our communities in all sections of the Union.

"Why further allude to facts which apply to almost every kind of mechanical pursuit with overwhelming force? Why allude to them at all? Only that, if possible, we may press upon you motive for exertion, and awake a laudable ambition to elevate from its low position southern mechanic art. Can this be done by this association? Doubtless to some extent. The very object in view in our organization is to invite you all,—every one who possesses the spirit of a native or adopted son of the South, to do something to elevate his profession. We wish to bring you before your fellow citizens by an exhibition of your skill—we wish to encourage each and all of you to feel that you can excel in your own particular branch of work, and we desire to show to the world that our southern artizans can compete with others if placed in as favorable circumstances. We organize, too, for the purpose of inviting you to prepare articles of your own work for public exhibition at some future period, under the auspices of the Society, and to this exhibition we earnestly invite manufacturers of every kind in wool and cotton, and artizans in every department, to send such specimens of their skill as may be suited for such a display. We extend our invitation, too, to those among us who are engaged in the more delicate labor of forming articles of ornament and decoration, and whose quiet and beautiful industry is scarcely known even by those with whom they daily associate.

"But we have higher aims in our Association than that of exhibiting specimens of skill in mechanics or manufactures. We desire to cultivate the mental faculties—we wish to open facilities, by which every one so disposed may be made more acquainted with the great secret of "*power*" and "*wealth*"—KNOWLEDGE; and we do most devoutly believe and maintain that every advance in mechanics and manufactures, in this country, is a direct aid in advancing education and refinement. In general, it will be seen that a high grade of common school education among the masses of our people, can only be found where population is somewhat condensed. The population in this State being agricultural, is very sparse, scattered over a large tract of country, and deprived of those advantages which are accessible to those who live in towns and villages. It is not surprising that a vast number of our industrious and worthy people are excessively ignorant; but facts speak louder than words, and to these we again resort. There has lately been established, near our city, a factory which employs one hundred operatives, gathered from the city and surrounding country. Of this number, it has been found that more than one-half are unable to write their names upon the treasurer's pay roll. To this it may be said, that of this number there are many foreigners and their children, and that this is scarcely a fair exhibit. Well, admit the objection, and we will refer you to another factory where this objection can have no force. There are now gathered in Graniteville six hundred people from the neighboring districts, of which one hundred and fifty are employed in the mill; of this one hundred and fifty, there are not over sixty